GEOTECHNICAL ENGINEERING REPORT
CAMINADA HEADLANDS BACK BARRIER
MARSH CREATION INCREMENT I (BA-171)
MARSH FILL SETTLEMENT RE-EVALUATION

LAFOURCHE & JEFFERSON PARISHES, LOUISIANA

Ardaman & Associates, Inc.

OFFICES

Orlando - 8008 S. Orange Avenue, Orlando, Florida 32809 - Phone (407) 855-3860
Bartow - 1525 Centennial Drive, Bartow, Florida 33830 - Phone (863) 533-0858
Baton Rouge - 316 Highlandia Drive, Baton Rouge, Louisiana 70884 - Phone (225) 752-4790
Cocoa - 1300 N. Cocoa Blvd., Cocoa, Florida 32922 - Phone (321) 632-2503
Fort Myers - 9970 Bavaria Road, Fort Myers, Florida 33913 - Phone (239) 768-6600
Miami - 2608 W. 84th Street, Hialeah, Florida 33016 - Phone (305) 825-2683
Monroe - 338 Fontana Road, Monroe, Louisiana 71203 - Phone (318) 343-0900
New Orleans - 1305 Distributors Row, Suite I, Jefferson, Louisiana 70123 - Phone (504) 835-2593
Port St. Lucie - 460 Concourse Place NW, Unit 1, Port St. Lucie, Florida 34986 - Phone (772) 878-0072
Sarasota - 78 Sarasota Center Blvd., Sarasota, Florida 34240 - Phone (941) 922-3526
Shreveport - 7222 Greenwood Road, Shreveport, Louisiana 71119 - Phone (318) 636-3673
Tallahassee - 3175 West Tharpe Street, Tallahassee, Florida 32303 - Phone (850) 576-6131
Tampa - 3925 Coconut Palm Drive, Suite 115, Tampa, Florida 33619 - Phone (813) 620-3389
West Palm Beach - 2200 North Florida Mango Road, Suite 101, West Palm Beach, Florida 33409 - Phone (561) 687-8200

MEMBERS:
A.S.F.E.
American Concrete Institute
ASTM International
Florida Institute of Consulting Engineers

Ardaman & Associates, Inc.
Geotechnical, Environmental and
Materials Consultants

May 10, 2018
AAI File: 17-2810B

Coastal Protection and Restoration Authority
P.O. Box 44027
Baton Rouge, LA 70804

Attention: Ms. Renee Bennett– PMP
Renee.s.bennett@la.gov

Re: Geotechnical Engineering Report
Caminada Headlands Back Barrier Marsh Creation Increment I (BA-171)
Marsh Fill Settlement Re-Evaluation
Lafourche & Jefferson Parishes, Louisiana

We have completed a re-evaluation of the marsh fill settlements for the Caminada Headlands Back Barrier Marsh Creation Increment I (B-171) based on the updated soil properties obtained from our Offshore Borrow Investigation. A summary of the methods of analysis and results are provided in the attached Geotechnical Engineering Report. This work was authorized by Task #3 Notice to Proceed dated January 3, 2018 under our existing contract No. 4400012418 with the Coastal Protection and Restoration Authority (CPRA).

Sincerely,
ARDAMAN & ASSOCIATES, INC.
LAPELS No. EF. 0001680

STATE OF LOUISIANA
ROBERT J. WERNER
License No. 36633
PROFESSIONAL
ENGINEER
IN
CIVIL ENGINEERING

5/10/18

George F. Segre Quilichini, P.E.
Project Engineer

Robert J. Werner, P.E.
Principal Engineer

Attachments: -Flash Drive

1305 Distributors Row, Suite I, Jefferson, Louisiana 70123 Phone (504) 835-2593 Fax (504) 835-2982
Louisiana: Alexandria, Baton Rouge, Monroe, New Orleans, Shreveport
Florida: Bartow, Cocoa, Fort Myers, Miami, Orlando, Port St. Lucie, Sarasota, Tallahassee, Tampa, West Palm Beach

TABLE OF CONTENTS

GEOTECHNICAL ENGINEERING REPORT
CAMINADA HEADLANDS BACK BARRIER MARSH CREATION INCREMENT I (BA-171)
MARSH FILL SETTLEMENT RE-EVALUATION

LAFOURCHE & JEFFERSON PARISHES, LOUISIANA

This Draft Geotechnical Engineering Report summarizes the results of our re-evaluation of the marsh fill settlement curves for the Caminada Headlands Back Barrier Marsh Creation Increment I (BA-171) project. Preliminary analyses have previously been performed by GeoEngineers as documented in their Report No. 16715-012-04, dated March 18, 2016. A copy of that report, along with supporting data and calculations was provided to us by CPRA. The prior settlement analyses considered results of an offshore borrow area investigation previously performed by Eustis Engineering as documented in their Report No. 22729, dated August 3, 2015, but also incorporated assumed compressibility and time-rate of consolidation properties of the dredged fill in light of limitations associated with the testing undertaken during the original borrow investigation. More recently, Ardaman and Associates, Inc. (Ardaman) was tasked with performing a supplemental offshore borrow investigation for the Increment I (BA-171) project in conjunction with our borrow investigation for the Increment II (BA-193) project. Ardaman was also tasked with selecting updated fill properties based on results of the supplemental borrow investigation and performing updated analyses to confirm or revise the original BA 171 settlement curves. A copy of the offshore borrow investigation performed by Ardaman Report No. 17-2810A and dated February 9, 2018 is provided in Appendix A of this report. Results of the foundation settlements along with the marsh fill self-weight consolidation settlement calculations performed in this report are provided in Appendix B.

SECTION 1. GENERAL PROJECT INFORMATION

1.1 Project Description

According to the Coastal Protection and Restoration Authority (CPRA), the Caminada Headland has experienced some of the highest shoreline retreat rates in Louisiana, with recent measurements exceeding 80 feet per year between 2006 and 2011. The Caminada Headlands Back Barrier Marsh Creation Increment I (BA-171) project has two main goals: i) to create and/or nourish 385 acres of back barrier marsh through the use of pumped sediment from an offshore borrow site; and ii) to create a platform upon which beach and dune can migrate, thereby reducing the likelihood of breaching during storm events. The proposed project is expected to slow the current trend of degradation in the headland. According to CPRA, the Caminada Headland has experienced some of the highest shoreline retreat rated in Louisiana, with recent measurements exceeding 80 feet per year between 2006 and 2011. These increased losses are said to occur in the wake of Hurricanes, which formed breaches in the headlands, that remained open for extended periods of time, thus increasing the net export of sediment from the headlands.

The scope of work associated with the marsh fill settlement re-evaluation for this project consisted of reviewing the data and analyses provided in the March 2016 GeoEngineers' Report; performing long-term settlement analyses of the dredge fill material based on the updated offshore borrow investigation laboratory data using the U.S. Army Corps of Engineers (USACE) computer program "Primary consolidation, Secondary compression, and Desiccation of Dredge Fill" (PSDDF); and, generating settlement curves over the 20 year project life for different fill heights while taking into account the consolidation of the subsurface soils and self-weight consolidation of the marsh fill.

1.2 Site Location and Description

The project area is defined by CPRA as the area south of Louisiana Highway 1 between Belle Pass and Caminada Pass, directly behind Caminada Headland beach covering the areas in and around Bay Champagne and areas east of Bayou Moreau. Figure 1 shows the approximate extent the various marsh creation areas along with the location of the proposed offshore borrow site.

The offshore Borrow Site is located approximately 1½ to 2 miles offshore from the proposed marsh creation area, and encompasses and area approximately 0.6 square miles in size. Approximate coordinates for the center of the borrow area are 29° 09' 18.83" N, and 90° 06' 41.92" W (NAD83).

SECTION 2. ANALYSES

2.1 Furnished Information

Ardaman was furnished by CPRA a series of documents pertaining to the March 2016 report by GeoEngineers for the original study. A copy of the furnished reports are provided in Appendix A. The complete list of documents, including calculations and supporting information, are listed below:

1. A document entitled "BA-171 Final GER 3-18-2016.pdf", the Draft Geotechnical Engineering Report provided by GeoEngineers to CPRA, dated March 18, 2016. The draft report contains a discussion of the site geology, and subsurface conditions along with recommendations with regard to containment dike geometry, bearing capacity, slope stability and settlement. The report also includes results of the self-weight consolidation analyses of the marsh fill and foundation settlements along with an estimate of cut-to-fill volumes.

2. A document entitled "Calculations Package 1671501204.pdf", a document detailing the calculations, field notes, initial review comments and corrections, etc. generated through development of the Geotechnical Engineering Report. The report also includes a series of documents detailing the assumptions and procedures followed for the various

calculations (slope stability, bearing capacity, consolidation, etc.) along with the hand calculations or outputs from the various computer programs used in design.

3. A spreadsheet entitled "Input-Reconstructed Curves Caminada Project.xls" which summarizes the development of the input parameters for use in the PSDDF program. The file also contains a copy of the outputs generated for each of the PSDDF cases analyzed.

4. A "zip file" containing the input and output files generated by the USACE computer program PSDDF containing the following files:

    a. Consolidation curves for use with Boring B-2:
        i. File names: 2201, 2202, 2401, 2402

    b. Consolidation curves for use with Boring B-5:
        i. File names: 5201, 5202, 5401, 5402

    c. Consolidation curves for use with Boring B-6:
        i. File names: 6201, 6202, 6401, 6402

5. A series of excel spreadsheets which summarize the results of the consolidation settlements for both the marsh fill and foundation.
    a. B-2 Sett Adj and Time Rate – water @ 0.2 ft. Fill @ +2.0 ft. even lifts.xlsx
    b. B-2 Sett Adj and Time Rate – water @ 0.2 ft. Fill @ +2.0 ft. second lift.xlsx
    c. B-2 Sett Adj and Time Rate – water @ 0.2 ft. Fill @ +4.0 ft. even lifts.xlsx
    d. B-2 Sett Adj and Time Rate – water @ 0.2 ft. Fill @ +4.0 ft. second lift.xlsx

    e. B-5 Sett Adj and Time Rate – water @ 0.2 ft. Fill @ +2.0 ft.xlsx
    f. B-5 Sett Adj and Time Rate – water @ 0.2 ft. Fill @ +2.0 ft. second lift.xlsx
    g. B-5 Sett Adj and Time Rate – water @ 0.2 ft. Fill @ +4.0 ft.xlsx
    h. B-5 Sett Adj and Time Rate – water @ 0.2 ft. Fill @ +4.0 ft. second lift.xlsx

    i. B-6 Sett Adj and Time Rate – water @ 0.2 ft. Fill @ +2.0 ft.xlsx
    j. B-6 Sett Adj and Time Rate – water @ 0.2 ft. Fill @ +2.0 ft. second lift.xlsx
    k. B-6 Sett Adj and Time Rate – water @ 0.2 ft. Fill @ +4.0 ft.xlsx
    l. B-6 Sett Adj and Time Rate – water @ 0.2 ft. Fill @ +4.0 ft. second lift.xlsx

6. A spreadsheet entitled "Input-Reconstructed Curves Caminada Project.xls" which summarizes the development of the input parameters for use in the PSDDF program. The file also contains a copy of the outputs generated for each of the PSDDF cases analyzed.

2.2 Review of Furnished Information and Prior Analyses

Ardaman reviewed the original March 2016 design report along with the data, assumptions and analytical methods used by Geoengineers to estimate the consolidation settlements of the foundation soil and self-weight consolidation of the marsh fill.

We intended to begin the re-evaluation by perfoming "verification" analyses wherein the properties of the foundation soils and dredged fill selected or assumed for use in the original analyses would be adopted to confirm that our analytic methods achieved results comparable to the settlement curves included in the March 2016 report. However, because the in-house computer program used by GeoEnginees was not provided, replication of the original analyses for the foundation soil compression component of the settlements curves could not be achieved. Moreover, certain inconsistencies and the missing input data precluded us from replicating the foundation soil settlements. We did however perform a series of verification analyses of the dredged fill self-weight consolidation using the USACE computer program "*Primary Consolidation, Secondary Compression, and Desiccation of Dredged Fill*", for Windows (*PSDDF-W*), Version 2.1. These analyses used the same properties and fill rate sequences assumed during the original design analyses and resulted in comparable results. Moving forward, Ardaman re-evaluated the foundation parameters and developed our own interpretation of design parameters and boundary conditions for use in our analyses. In terms of the difference between the furnished results and those obtained with the updated set of design parameters, the observable end-result is within the same order of magnitude, as discussed with CPRA during a teleconference on March 5, 2018. Figures 2 through 4 contain the laboratory test data depicted on GeoEngineers' borings logs, and plots the data with elevation. Figures 5 through 7 summarize the Ardaman's interpretation of design parameters for the foundation elements.

2.3 Design Soil Parameters – Marsh Fill

During our previously performed Offshore Borrow Area Investigation Data Report, a series of settling column and slurry consolidation tests were performed on three composite samples. The composite samples were prepared to be representative of the conditions that could be generated by the dredging process across the borrow area. Results of the laboratory testing program led to the development of input parameters for use in self-weight consolidation analyses. The following tables summarizes the results of these tests, which were used in all of our analyses.

TABLE 1 - SUMMARY OF INPUT PARAMETERS FOR PSDDF

Parameter	Composite V-1	Composite V-2	Composite V-3
Avg. Compression Zone Void Ratio	8.7	7.7	6.7
Compression Index, C_c	1.213	1.024	0.803
Recompression Index, C_r	0.243	0.205	0.161
Secondary Compression Ratio, C_α	0.042	0.036	0.028
C_α/C_c	0.035	0.035	0.035
C_r/C_c	0.200	0.200	0.200
Specific Gravity, G_S	2.71	2.79	2.59
Void Ratio at Saturation, e_{SL}	3.94	3.37	3.01
Void Ratio at Desiccation, e_{DL}	2.13	1.99	1.91

TABLE 2 – VOID RATIO AND PERMEABILITY RELATIONSHIPS USED IN PSDDF

Composite V-1			Composite V-2			Composite V-3		
Void Ratio	σ'_v (lb/ft^2)	K_v (ft/day)	Void Ratio	σ'_v (lb/ft^2)	K_v (ft/day)	Void Ratio	σ'_v (lb/ft^2)	K_v (ft/day)
9.29	"0"*	1.63000	9.07	"0"	2.13000	8.93	"0"	1.50000
5.32	1	0.03371	4.75	1	0.01963	3.93	1	0.07341
5.01	3	0.02570	4.46	3	0.01503	3.45	3	0.04150
4.41	6	0.01459	3.95	6	0.00909	2.96	6	0.02145
3.90	12	0.00845	3.50	12	0.00552	2.54	12	0.01118
3.48	24	0.00510	3.15	24	0.00354	2.29	24	0.00718
2.87	48	0.00217	2.63	48	0.00168	2.03	48	0.00424
2.43	96	0.00104	2.27	96	0.00092	1.75	96	0.00225
2.03	192	0.00047	2.00	192	0.00054	1.53	192	0.00126
1.43	628	0.00010	1.50	628	0.00016	1.20	628	0.00044

σ'_v = Vertical Effective Stress.
K_v = Vertical Hydraulic Conductivity.
* = "zero stress" condition corresponding to the end of the sedimentation process and where the soil solids begin to form a continuous matrix. Related to e_{00} (void ratio at zero stress).

Figure 8 presents a graphical representation of the void ratio, vertical effective stress, and vertical hydraulic conductivity of the three composite samples alongside the assumed properties of the original design analyses. On the upper right-hand graph presented on Figure 8, hydraulic conductivity and vertical effective stress are plotted on a log-log scale. The data indicate that the original analyses assumed a lower hydraulic conductivity, which prolongs the consolidation process. One the upper left-hand graph, vertical effective stress and void ratio are plotted on a semi-log scale, and indicate that the original analyses assumed a more open structure within the soil matrix (larger void ratio at a given effective stress state), which would result in a thicker soil layer.

2.4 Consolidation Analyses

Post construction subsidence of the marsh creation areas will occur as a result of "self-weight" consolidation and drained creep of the dredged fill, primary and secondary consolidation of the *in-situ* marsh soils induced by placement of the fill, and potential seasonal desiccation of the fill surface. Settlement analyses were performed using the USACE computer program "*Primary Consolidation, Secondary Compression, and Desiccation of Dredged Fill*", for Windows (*PSDDF-W*), Version 2.1 for the dredged fill material and the *Settle3D* program for the underlying *in-situ* soils. Consideration was given to assumed fill increments and ramp-loading rates.

The PSDDF program performs finite difference calculations considering a material coordinate system capable of observing the large strains associated with dredged material deposition and self-weight consolidation. The one-dimensional model is capable of considering a "multi-lift" sequencing of dredged fill placement, with the thickness of each "lift" being the thickness of the slurry immediately prior to the initiation of the consolidation process.

Consolidation parameters related to self-weight consolidation of the dredged materials, in terms of relationships between void ratio, effective stress, and permeability were selected based on results of settling column and slurry consolidation tests performed for the February 9, 2018 Offshore Borrow Area Data Report (Table 2). The input of parameters for rainfall and evaporation used in the original GeoEngineers' analyses were adopted for our re-evaluation. Pan evaporation rates were obtained from the LSU-Ben Hur Farm Station, and precipitation rates were obtained from the USC00163807 monitoring station located in Grand Isle, LA.

Based on furnished information, the elevation of marsh platforms and the frequency with which they flood has a significant impact on the marsh vegetation, and in turn, marsh health. The 95% Design Report for this project indicates that the target range for marshlands should be between a 20% chance of inundation (flooding) and 80% chance of inundation. The report also indicates a 20-year eustatic and relative sea level rise of about 0.449 feet, assuming that subsidence and accretion in the project area cancel each other out. Therefore, the target marsh elevation for this project was fixed between the 20% and 80% inundation elevation over the design life of this project. The target marsh elevations are summarized in the following table.

TABLE 3 – TARGET MARSH ELEVATION OVER TIME

Time (year)	20 % Inundation Elevation (ft., NAVD88)	80% Inundation Elevation (ft., NAVD88)
2017	+0.74	-0.47
2037	+1.19	-0.02

2.4.1.1 Marsh Fill - Foundation Settlements

Post construction subsidence of dredged fill surfaces resulting from primary consolidation of the underlying *in-situ* soil were calculated using the properties discussed previously. Analyses were performed for the soil profiles corresponding to the furnished Soil Borings B-2, B-5, and B-6. Based on discussions with CPRA on March 5, 2018, the marsh creation area will be subdivided into discrete cells. The rate at which hydraulically placed dredged material will fill the cells will depend on the size, which will influence the sedimentation regime of the fill material and the load imposed on the foundation subsoils. Analyses were performed assuming various fill rates. The primary consolidation calculations are included in Appendix B.

2.4.1.2 Marsh Fill - Consolidation and Shrinkage

Marsh creation will be accomplished using hydraulic dredging of native clay from a designated offshore borrow area. Once deposited via dredge discharge into the marsh creation areas, the fill will initially settle under water and begin to compress under its own weight and will then consolidate under the weight of gradually added fill. The initial gravity settling and subsequent "compression settling" behavior of the proposed borrow materials were characterized by performing three settling column tests. Results of these tests are presented and discussed in our Offshore Borrow Area Investigation Data Report dated February 9, 2018. Consolidation behavior of the fill was investigated by performing one incremental one-dimensional slurry consolidation test on each of the three composite samples (i.e. Composite V-1, V-2, and V-3). Results of settling column and slurry consolidation tests were evaluated and used to estimate initial settled compressed void ratios and to select fill properties and consolidation parameters for use in settlement analyses included in Appendix B.

Primary consolidation analyses for the dredged fill are included in Appendix B. The analyses were performed using the properties of the V-1 composite sample, which was obtained from the designated borrow area for the Caminada Increment I Marsh Creation project. These analyses account for a portion of the self-weight consolidation that will occur during the dredge fill placement process (and hence is compensated for through continued fill placement up until the design surface elevation is achieved). Based on discussions with CPRA on March 5, 2018, it is understood that the marsh creation area will be subdivided into cells. Depending on the number and size of these cells, the hydraulically placed dredged material will fill the cells at different rates, which will influence the sedimentation regime of the fill material. Total post-construction marsh area subsidence related to primary consolidation of the dredged fill is estimated to be on the order of 5 feet from the idealized "cumulative lift thickness" and is expected to occur within the first few years after fill placement. Subsequent secondary compression is expected to result in up to one additional inch of settlement over a 20-year post construction period. Figure 9 details the fill-rate sequences, and the following table provides a summary of the cases considered in the analyses.

TABLE 4 – SETTLEMENT CURVE CASES

Case Considered	Description	Specific Gravity of Dredge Fluid	Density of Solids Percent by Volume
Case 1	60-Day Construction Period, 1-lift sequence	≈ 1.15	≈ 9
Case 2	150-Day Construction Period, 2-lift sequence	≈ 1.15	≈ 9
Case 3	30-Day Construction Period, 1-lift sequence	≈ 1.20	≈ 13

It is our understanding that the marsh containment berms will be breached at strategic locations at some time after construction to allow more natural inflow-outflow patterns. Until such time the newly created marsh area is expected to remain essentially saturated (considering particularly that rainfall normally exceeds evaporation in southern Louisiana). As illustrated in the settlement time curves on Figures 10 through 27, subsidence of the marsh surface occurs most rapidly during the early post-construction years. It seems likely that capillarity and rainfall will act to maintain essentially saturated conditions. Assuming that accumulation of organic matter approximately compensates for moisture content reduction within the vegetated root zone, desiccation and shrinkage will not have a significant impact on post-construction behavior of the marsh creation area. This being said, the probability of a particularly dry season where evaporation rates exceed rainfall is not out of the question. Desiccation and shrinkage associated with a dry season could result in an additional compression of about six inches at any time post-breaching of the containment berms. Figures 10 through 27 contain a dashed line indicating the probable shrinkage and/or desiccation of the marsh fill associated with this of type event. It should be noted that the lines representing the top of the containment berm on Figures 10 through 27 were developed for a hypothetically instantaneous containment berm construction just prior to the start of filling. In reality, to compensate for settlement of the berm, some maintenance of the berm crest may be required to restore the crest elevation (freeboard) between the time it is actually constructed and the time that filling begins.

SECTION 3. REFERENCES:

Becker, D. E., Crooks, J. H. A., Been, K., and Jefferies, M. B. (1987), "*Work as a Criterion for Determining In-Situ and Yield Stresses in Clays*", Canadian Geotechnical Journal, Vol. 24, No. 4, pp 549-564.

Cargill, K. W. (1982). "Consolidation of Soft Layers by Finite Strain Analysis," Miscellaneous Paper GL-82-3, US Army Engineer Waterways Experiment Stations, Vicksburg, MS.

Cargill, K. W. (1985). "Mathematical Model of the Consolidation/Desiccation Processes in Dredged Material," Technical Report D-85-4, US Army Engineer Waterways Experiment Stations, Vicksburg, MS.

Casagrande, A. (1936), "*The Determination of the Pre-consolidation Load and its Practical Significance*", Proceedings, First International Conference on Soil Mechanics and Foundation Engineering, Cambridge, Vol. 3, pp 60-64.

CPRA 95% Design Report BA-171 Caminada Headland Back Barrier Marsh Creation Project, Coastal Wetland Planning, Protection, and Restoration Act PPL 23. October 14, 2016.

Germaine, J., and Germaine, A. (2009). "*Geotechnical Laboratory Measurements for Engineers*". Hoboken, New Jersey: John Wiley and Sons, Inc.

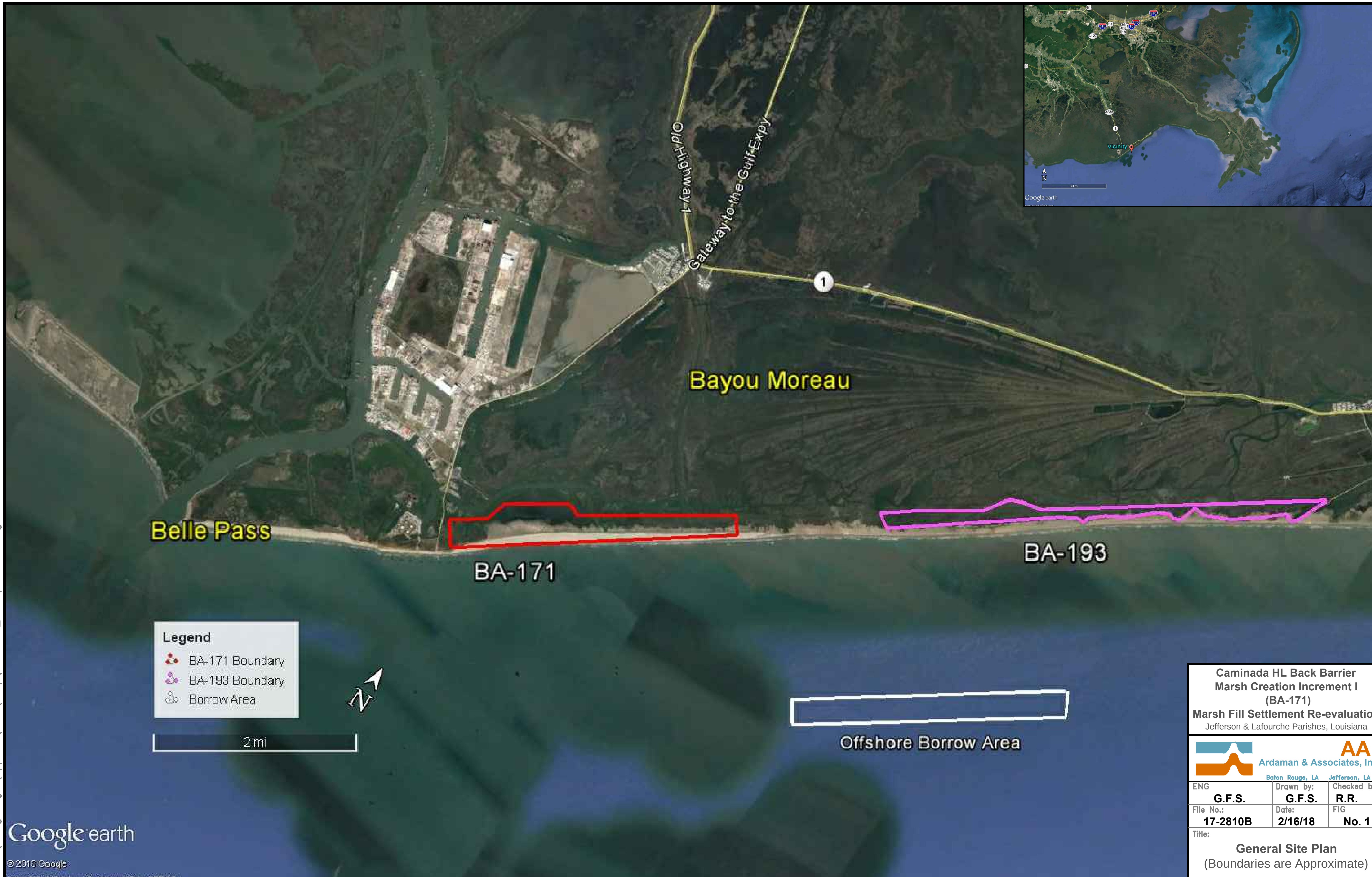
Mesri, G. and Castro (1987), "*C_α/C_c Concept and K_0 during Secondary Compression*". ASCE, JGGE, 113(3), pp 230-247.

Stark, T.D., Choi, H., Schroeder, P.R. (2005). "Settlement of Dredged and Contaminated Material Placement Areas I: Theory and Use of PSDDF". ASCE, J. Waterway, Port, Coastal Engineering. 131(2): 43-51.

Stark, T.D., Choi, H., Schroeder, P.R. (2005). "Settlement of Dredged and Contaminated Material Placement Areas II: PSDDF Input Parameters". ASCE, J. Waterway, Port, Coastal Engineering. 131(2): 52-61.

Stark, T.D., (2014). "Program Documentation and User's Guide: PSDDF – Primary Consolidation, Secondary Compression, and Desiccation of Dredged Fill – Microsoft Windows". Instruction Report EL-14-XX, US Army Engineer Waterways Experiment Stations, Vicksburg, MS.

FIGURES:



Caminada HL Back Barrier
Marsh Creation Increment I
(BA-171)
Marsh Fill Settlement Re-evaluation
Jefferson & Lafourche Parishes, Louisiana

AAI
Ardaman & Associates, Inc.
Baton Rouge, LA Jefferson, LA

ENG	Drawn by:	Checked by:
G.F.S.	G.F.S.	R.R.
File No.: 17-2810B	Date: 2/16/18	FIG No. 1

Title:
General Site Plan
(Boundaries are Approximate)

Feb 16, 2018 – 11:26am
C:\Users\George.Segre\appdata\local\temp\AcPublish_5196\Site Plan.dwg

Caminada Headlands Back Barrier Marsh Creation Increment I (BA-171) - Boring B-2

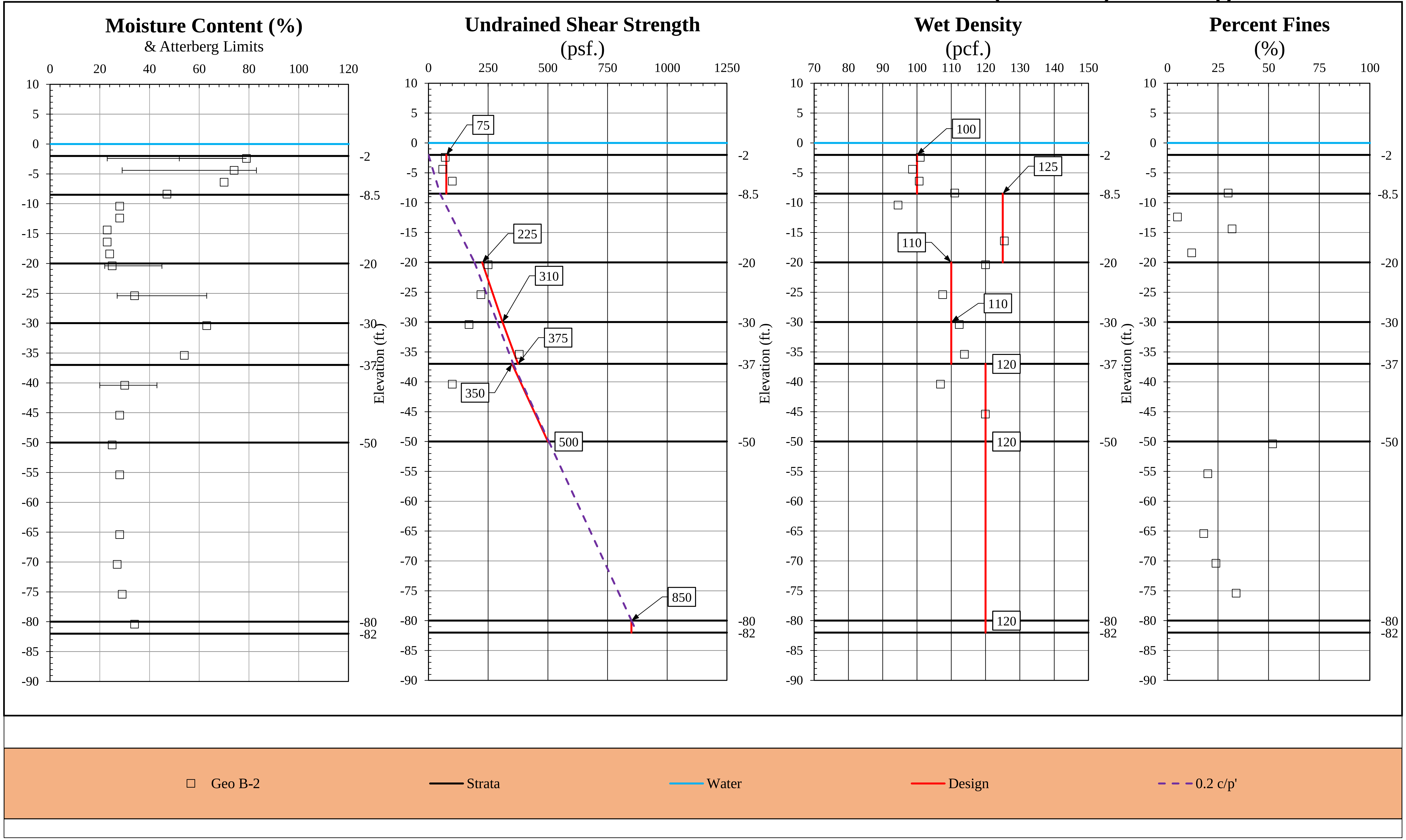
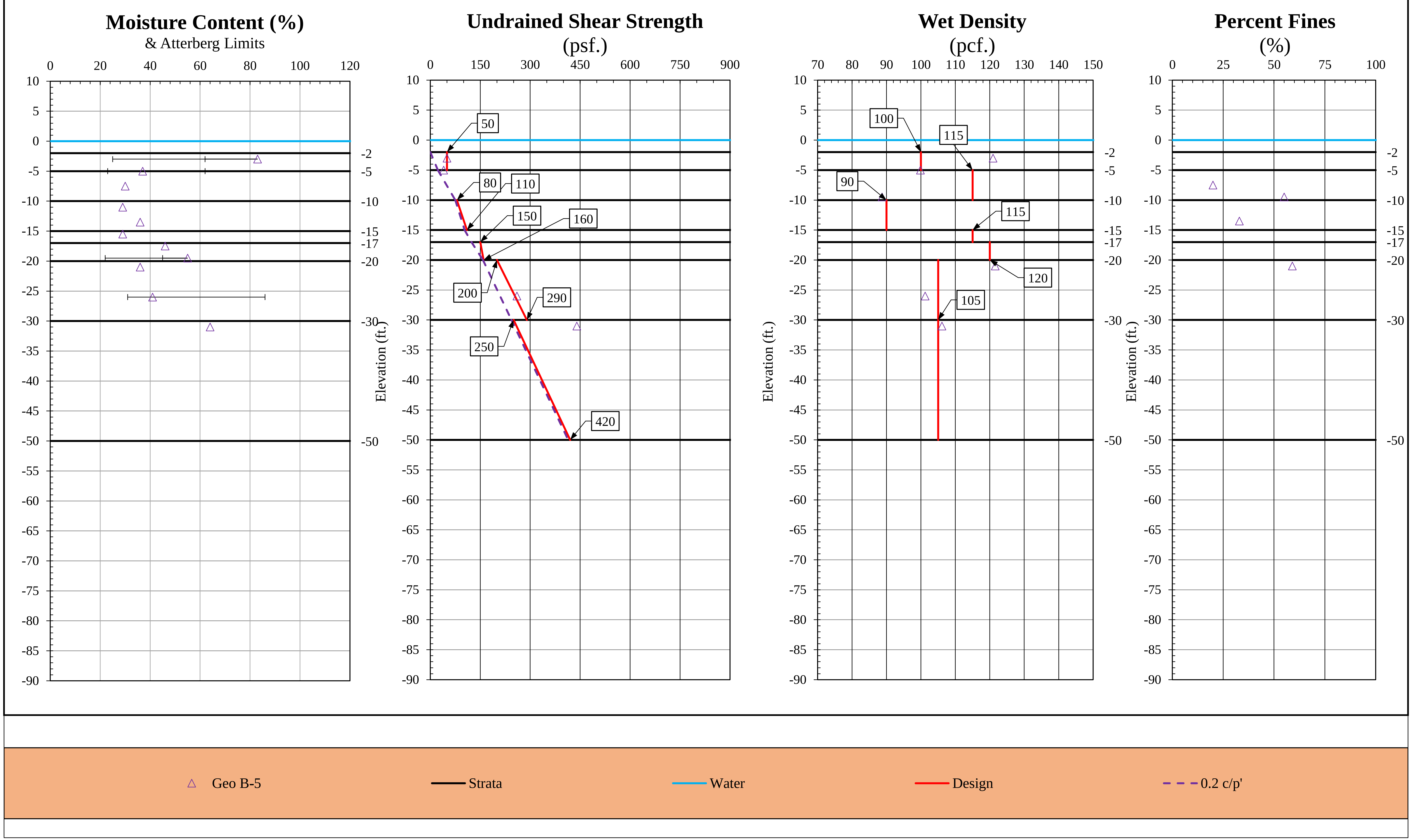


Figure No. 2

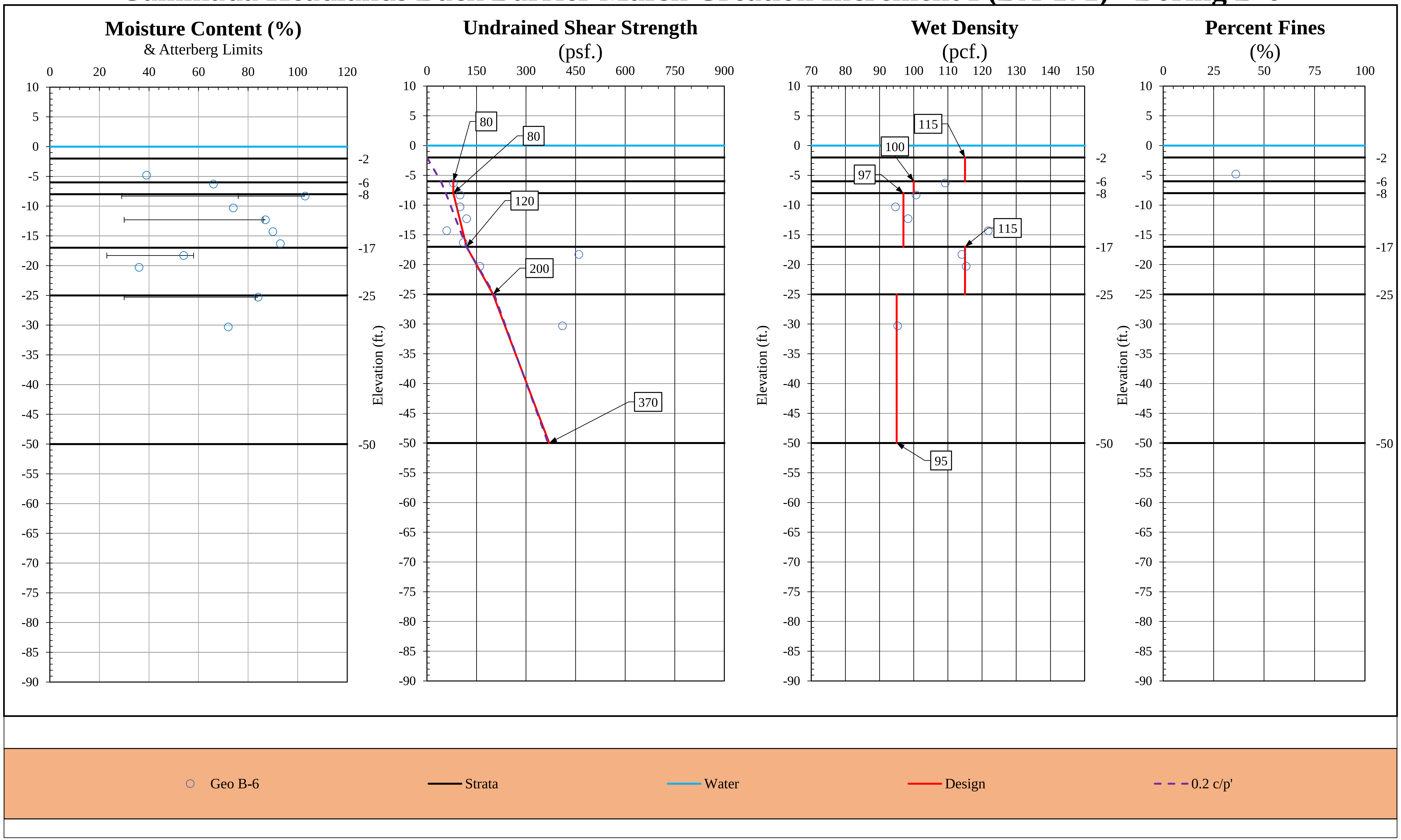
Caminada Headlands Back Barrier Marsh Creation Increment I (BA-171) - Boring B-5



Ardaman & Associates, Inc.

Figure No. 3

Caminada Headlands Back Barrier Marsh Creation Increment I (BA-171) - Boring B-6



Ardaman & Associates, Inc.

Figure No. 4

Caminada Headlands Backbarrier Marsh Creation (BA-171)

Lafourche Parish, Louisiana

SETTLEMENT PARAMETERS FOR B-2 (Ardaman's interpretation of GeoEngineers design parameters)

ELEV		THICK.	Drain at Bottom	COHESION	M.C	L.L	EQ. 1	UNIT WEIGHT		EQ. 2	EQ. 3	EQ. 4	DESIGN PARAMETERS				P_{avg} increment	P_t	Po	P_{max}	OCR[2]	Adopted[3]
								WET, γ_{tot}	DRY, γ_d				Adopted	Adopted	C_v[1]	$C_{v\ Model}$						
FEET		FEET	(--)	KSF	%	%	S.G	PCF	PCF	e_o	C_c	C_r	C_c	Cr	ft^2/day	ft^2/day	tsf	tsf	tsf	ksf		OCR
-2.6	-8.5	5.9	Y	0.075	75	68	2.70	100	57	2.025	0.75	0.135	0.750	0.135	0.01	0.050	0.05546	0.0000	0.0555	0.5085	4.6	4.6
-8.5	-20.0	11.5	--	--	29	--	2.70	125	97	0.783	--	--	--	--	--	--	0.17998	0.1109	0.2909	--	--	--
-20.0	-30.0	10.0	N	0.275	30	54	2.70	110	85	0.810	0.30	0.054	0.300	0.054	0.01	0.050	0.11900	0.4709	0.5899	1.2682	1.1	1.1
-30.0	-37.0	7.0	N	0.350	60	45	2.70	110	69	1.620	0.60	0.108	0.600	0.108	0.01	0.025	0.08330	0.7089	0.7922	1.5926	1.0	1.0
-37.0	-50.0	13.0	Y	0.450	30	43	2.70	120	92	0.810	0.30	0.054	0.300	0.054	0.01	0.050	0.18720	0.8755	1.0627	2.1253	1.0	1.0
-50.0	-79.0	29.0	--	--	28	--	2.70	120	94	0.756	--	--	--	--	--	--	0.41760	1.2499	1.6675	--	--	--
-79.0	-82.6	3.6	Y	0.850	34	32	2.70	120	90	0.918	0.34	0.061	0.340	0.061	0.01	0.050	0.05184	2.0851	2.1369	4.2738	0.9	1.0

Consolidation is Disabled (granular material)

Equations:

EQ. 1 S.G. = 2.60 to 2.70

EQ. 2 e0 = MC*(SG/Sat) [Assume Saturation = 100%]

EQ. 3 Cc = MC / 100

EQ. 4 $C_r = 0.18*C_c$

Note:

1 Cv values for materials were determined using the LL. Value employed in the model is 5 times greater than lab value.

2 OCR = (c/(p'* 0.2))^(1/0.8)

3 From Note 2, reviewing c/p line and consolidation test result; Assumed OCR =1 if OCR<1 from calculations

Caminada Headlands Backbarrier Marsh Creation (BA-171)																						
Lafourche Parish, Louisiana																						
SETTLEMENT PARAMETERS FOR B-5 (Ardaman's interpretation of GeoEngineers design parameters)																						
ELEV		THICK.	Drain at Bottom	COHESION	M.C	L.L	EQ. 1	UNIT WEIGHT		EQ. 2	EQ. 3	EQ. 4	DESIGN PARAMETERS				P_{avg} increment	P_t	Po	P_{max}	OCR[2]	Adopted[3]
								WET, γ_{tot}	DRY, γ_d				Adopted	Adopted	C_v[1]	$C_{v\ Model}$						
FEET		FEET	(--)	KSF	%	%	S.G	PCF	PCF	e_o	C_c	C_r	C_c	Cr	ft^2/day	ft^2/day	tsf	tsf	tsf	ksf		OCR
-2.0	-5.0	3.0	Y	0.050	80	80	2.65	100	56	2.120	0.80	0.144	0.800	0.144	0.030	0.15	0.02820	0.0000	0.0282	0.3220	5.7	5.7
-5.0	-10.0	5.0	--	--	30	--	2.70	115	88	0.810	--	--	--	--	--	--	0.06575	0.0564	0.1222	--	--	--
-10.0	-15.0	5.0	Y	0.100	33	45	2.70	90	68	0.891	0.33	0.059	0.330	0.059	0.080	0.40	0.03450	0.1879	0.2224	0.4570	1.0	1.0
-15.0	-17.0	2.0	--	--	33	--	2.70	115	86	0.891	0.33	0.059	0.330	0.059	0.080	0.40	0.02630	0.2569	0.2832	--	--	--
-17.0	-20.0	3.0	N	0.155	50	45	2.70	120	80	1.350	0.50	0.090	0.500	0.090	0.020	0.10	0.04320	0.3095	0.3527	0.7054	1.0	1.0
-20.0	-30.0	10.0	N	0.250	35	85	2.70	105	78	0.945	0.35	0.063	0.350	0.063	0.200	1.00	0.10650	0.3959	0.5024	1.1719	1.2	1.2
-30.0	-50.0	20.0	Y	0.375	60	85	2.70	105	66	1.620	0.60	0.108	0.600	0.108	0.020	0.10	0.21300	0.6089	0.8219	1.7201	1.0	1.0

Consolidation is Disabled (granular material)

Equations:

EQ. 1 S.G. = 2.60 to 2.70

EQ. 2 e0 = MC*(SG/Sat) [Assume Saturation = 100%]

EQ. 3 Cc = MC / 100

EQ. 4 C_r= 0.18*C_c

Note:

1 Cv values for materials were determined using the LL. Value employed in the model is 5 times greater than lab value.

2 OCR = (c/(p'* 0.2))^(1/0.8)

3 From Note 2, reviewing c/p line and consolidation test result; Assumed OCR =1 if OCR<1 from calculations

Caminada Headlands Backbarrier Marsh Creation (BA-171)																						
Lafourche Parish, Louisiana																						
SETTLEMENT PARAMETERS FOR B-6 (Ardaman's interpretation of GeoEngineers design parameters)																						
ELEV		THICK.	Drain at Bottom	COHESION	M.C	L.L	EQ. 1	UNIT WEIGHT		EQ. 2	EQ. 3	EQ. 4	DESIGN PARAMETERS				P_{avg} increment	P_t	Po	P_{max}	OCR[2]	Adopted[3]
								WET, γ_{tot}	DRY, γ_d				Adopted	Adopted	C_v[1]	$C_{v\ Model}$						
FEET		FEET	(--)	KSF	%	%	S.G	PCF	PCF	e_o	C_c	C_r	C_c	Cr	ft^2/day	ft^2/day	tsf	tsf	tsf	ksf		OCR
-2.3	-6.0	3.7	--	--	39	--	2.70	115	83	1.053	--	--	--	--	--	--	0.04866	0.0000	0.0487	--	--	--
-6.0	-8.0	2.0	N	0.080	66	45	2.70	100	60	1.782	0.66	0.119	0.660	0.119	0.100	0.50	0.01880	0.0973	0.1161	0.4068	1.8	1.8
-8.0	-17.0	9.0	N	0.100	90	80	2.70	97	51	2.430	0.90	0.162	0.900	0.162	0.008	0.04	0.07785	0.1349	0.2128	0.4621	1.1	1.1
-17.0	-25.0	8.0	N	0.150	45	60	2.70	115	79	1.215	0.45	0.081	0.450	0.081	0.010	0.05	0.10520	0.2906	0.3958	0.7916	0.8	1.0
-25.0	-50.0	25.0	Y	0.300	75	80	2.70	95	54	2.025	0.75	0.135	0.750	0.135	0.008	0.04	0.20375	0.5010	0.7048	1.4095	1.0	1.0

Equations:

EQ. 1 S.G. = 2.60 to 2.70

EQ. 2 e0 = MC*(SG/Sat) [Assume Saturation = 100%]

EQ. 3 Cc = MC / 100

EQ. 4 C_r= 0.18*C_c

Consolidation is Disabled (granular material)

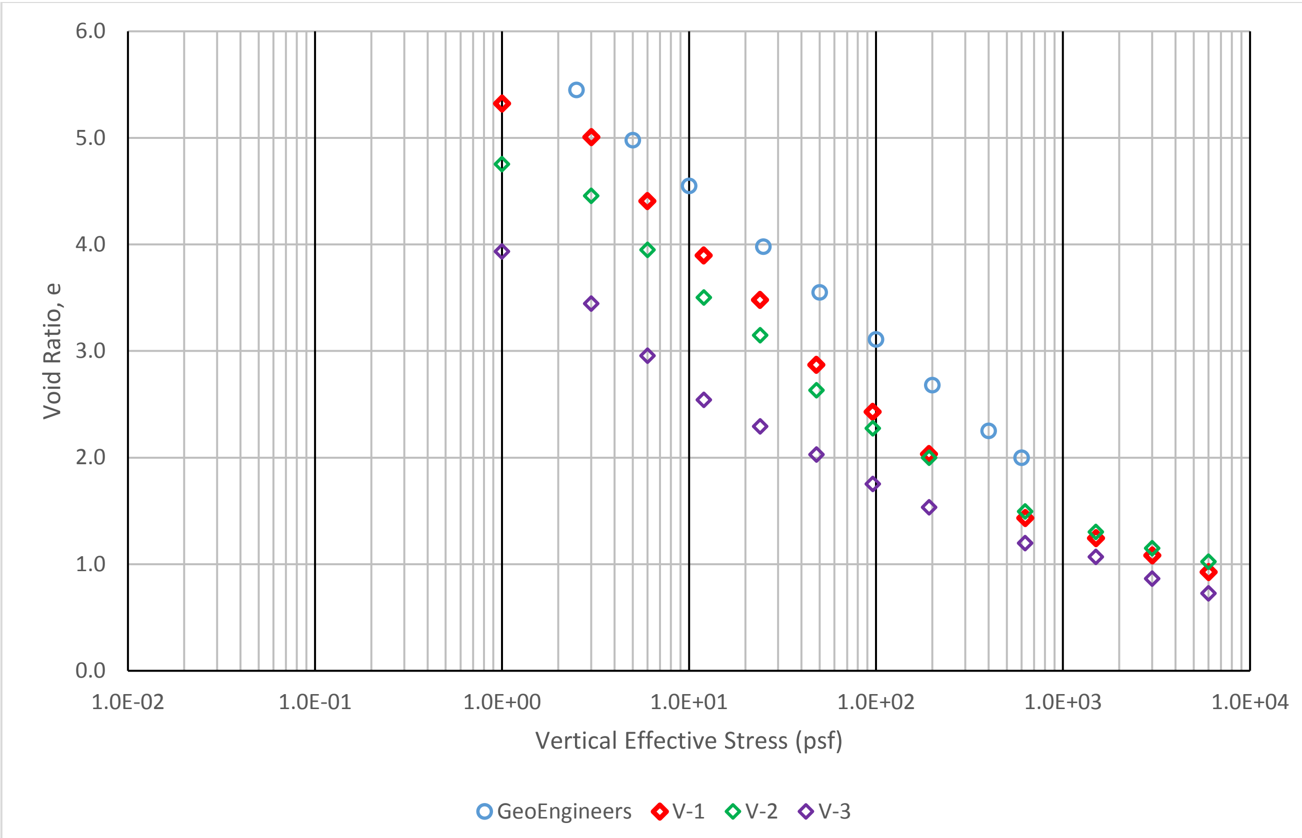
Note:

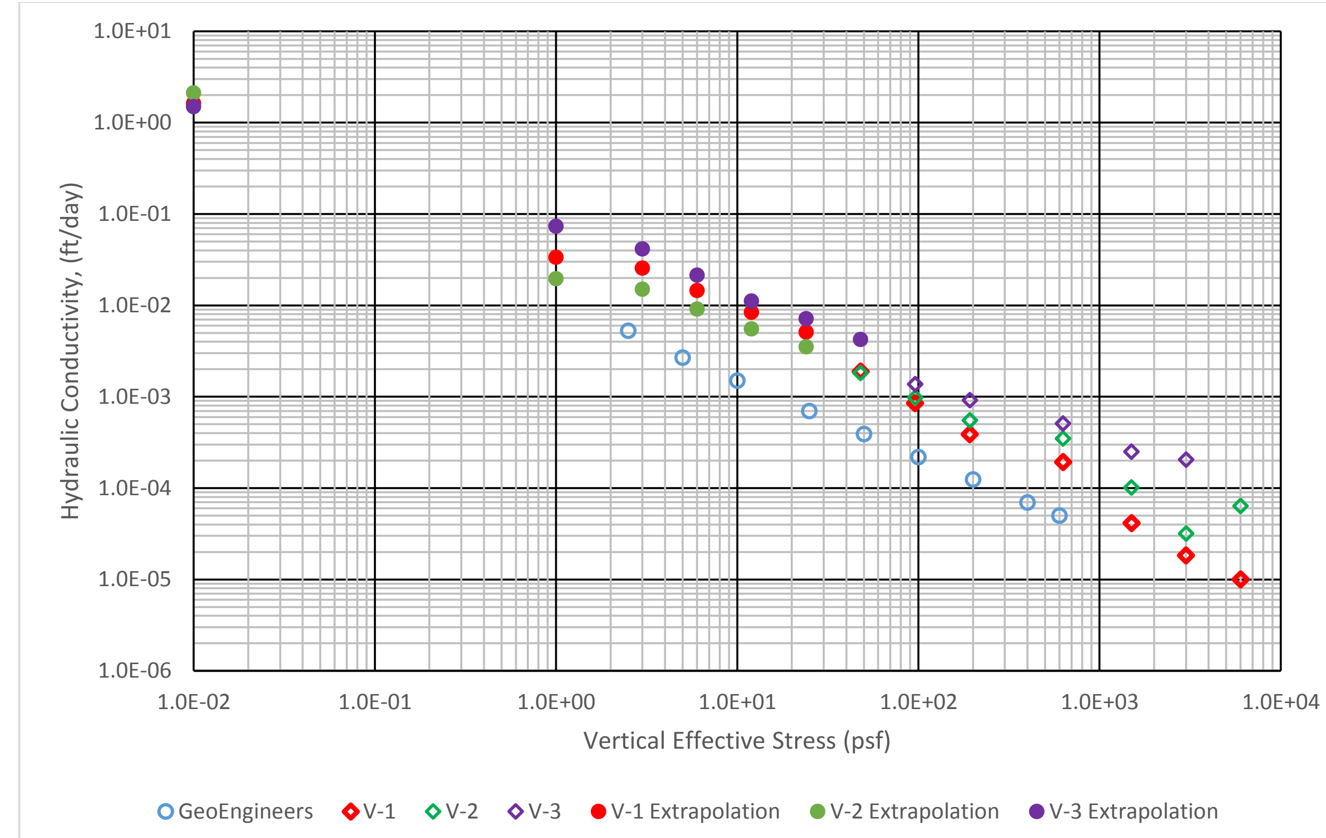
1 Cv values for materials were determined using the LL. Value employed in the model is 5 times greater than lab value.

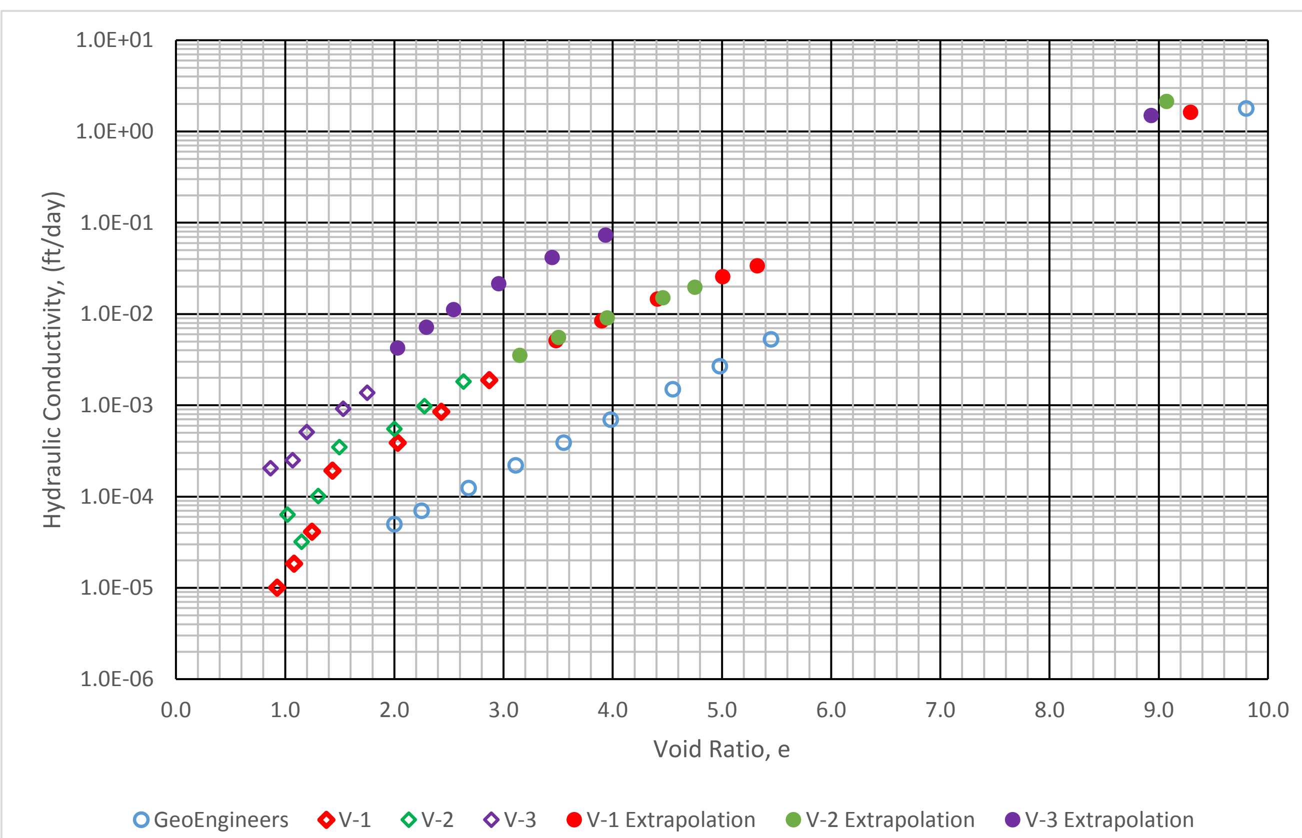
2 OCR = (c/(p'* 0.2))^(1/0.8)

3 From Note 2, reviewing c/p line and consolidation test result; Assumed OCR =1 if OCR<1 from calculations

Ardaman & Asocciates, Inc.
Slurry Consolidation and PSDDF Input - Marsh Fill Summary







	V-1		V-2		V-3		
	(12%)	(16%)	(12%)	(16%)	(12%)	(16%)	
Compression Zone Void Ratio =	8.58	8.74	8.49	6.86	7.37	5.98	
Avg. Compression Zone Void Ratio =	8.7		7.7		6.7		
Compression Index =	1.213		1.024		0.803		C_c from Slurry Consolidation Test
Ca/Cc =	0.035		0.035		0.035		
Cr/Cc =	0.200		0.200		0.200		
Specific Gravity =	2.71		2.79		2.59		
Liquid Limit =	74		62		50		
Plastic Limit =	22		21		16		
Plasticity Index =	52		41		34		
Void Ratio at Saturation Limit =	3.94		3.37		3.01		e_{SL} = 1.26 + (5.15*10^-2)(PI) eq. 10 Stark 2005
Void Ratio at Dessication Limit =	2.13		1.99		1.91		e_{DL} = 1.49 + (1.23*10^-2)(PI) eq. 11 Stark 2005
Crust Thickness (m) =	0.252		0.249		0.248		h_2 = 0.24 + (2.22*10^-4)(PI) eq. 15 Stark 2005
Crust Thickness (ft.) =	0.825		0.817		0.812		
Moisture at Dessication Limit =	26.4		25.2		19.2		w_{DL} = 1.2PI eq. 14 Stark 2005
Saturation at Dessication Limit =	0.34		0.35		0.26		
PSDDF Suggested Initial Void Raito	9.29		9.07		8.93		e_{00} = 8.25 + (0.02)(PI) eq. 1 Stark 2005

Ardaman & Associates, Inc.

Summary of Fill Sequences Considered for Marsh Creation Design

Case 1 - Fill Schedule Considered: 60-Day Construction Period for a Target Max. Fill Elevation of EL. +2

Composite Sample V-1, e_{00} = 9.25, Soil Boring B-2

Time	Fill Height
(day)	(ft.)
0	1.6
15	1.6
30	1.6
45	1.6
59	1.6
60	--

Composite Sample V-1, e_{00} = 9.25, Soil Boring B-5

Time	Fill Height
(day)	(ft.)
0	1.4
15	1.4
30	1.4
45	1.4
59	1.4
60	--

Composite Sample V-1, e_{00} = 9.25, Soil Boring B-6

Time	Fill Height
(day)	(ft.)
0	1.5
15	1.5
30	1.5
45	1.5
59	1.5
60	--

Case 2 - Multiple Lift Schedule Considered: 150-Day Construction Period for a Target Max. Fill Elevation of EL. +2

Composite Sample V-1, e_{00} = 9.25, Soil Boring B-2

Time	Fill Height
(day)	(ft.)
0	1.6
15	1.6
30	1.6
45	1.6
59	1.6
60	--
75	--
90	--
120	0.5
149	0.5

Composite Sample V-1, e_{00} = 9.25, Soil Boring B-5

Time	Fill Height
(day)	(ft.)
0	1.4
15	1.4
30	1.4
45	1.4
59	1.4
60	--
75	--
90	--
120	0.5
149	0.5

Composite Sample V-1, e_{00} = 9.25, Soil Boring B-6

Time	Fill Height
(day)	(ft.)
0	1.5
15	1.5
30	1.5
45	1.5
59	1.5
60	--
75	--
90	--
120	0.5
149	0.5

Case 3 - Fill Schedule Considered: 30-Day Construction Period for a Target Max. Fill Elevation of EL. +2
(Assume the fill rate includes a thicker slurry as well)

Composite Sample V-1, e_{00} = 7.29, Soil Boring B-2

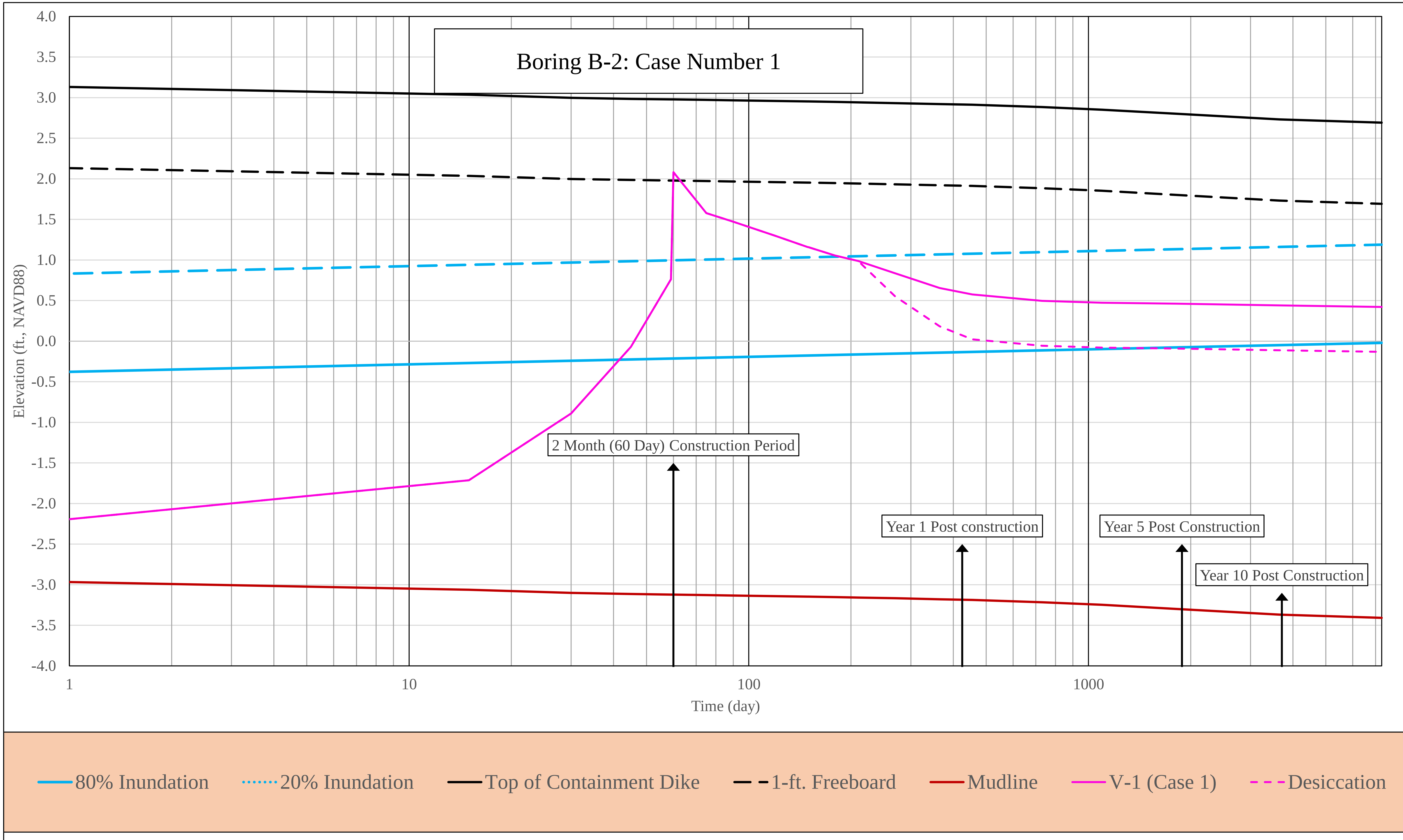
Time	Fill Height
(day)	(ft.)
0	1.5
7	1.5
14	1.5
21	1.5
29	1.5
30	--

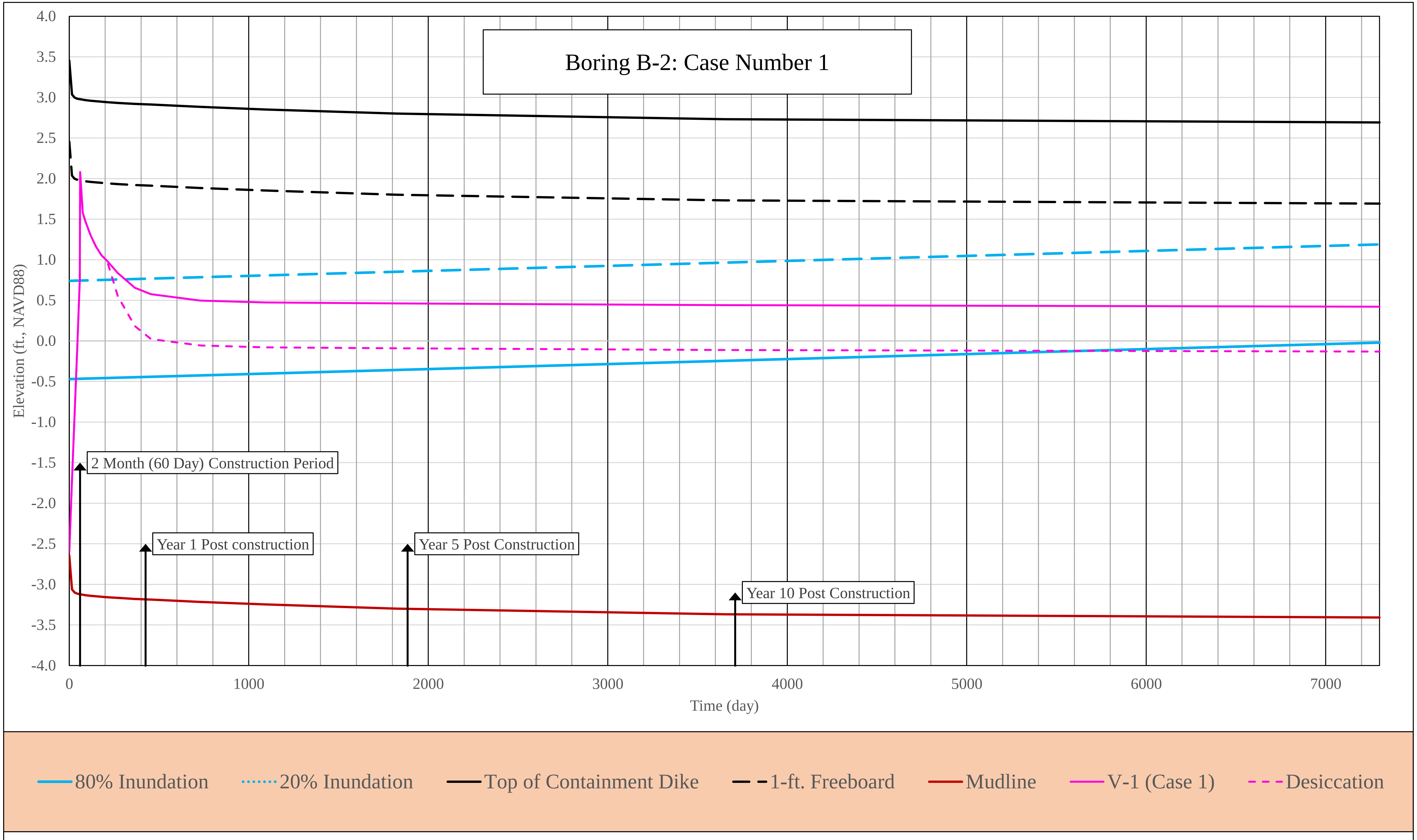
Composite Sample V-1, e_{00} = 7.29, Soil Boring B-5

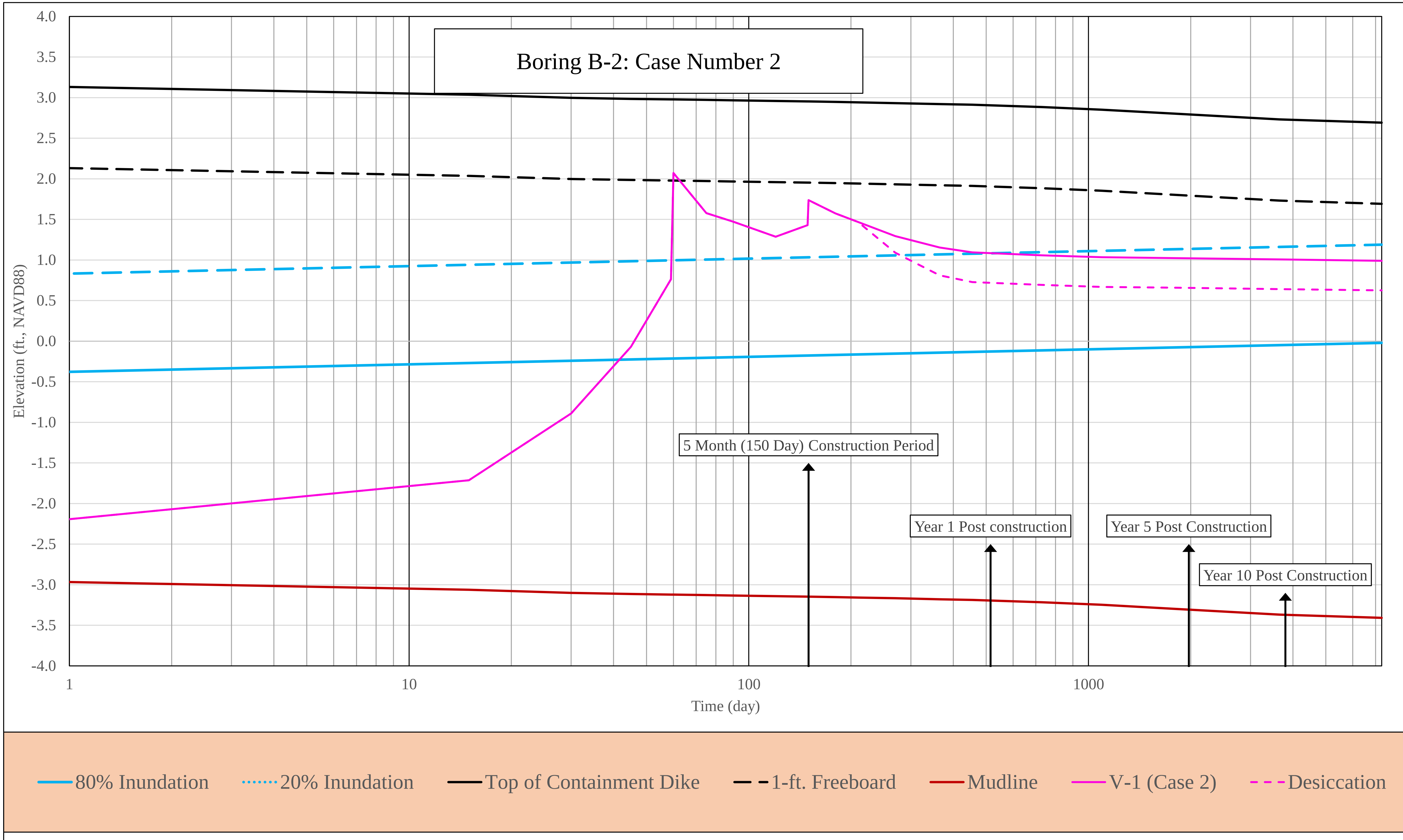
Time	Fill Height
(day)	(ft.)
0	1.35
7	1.35
14	1.35
21	1.35
29	1.35
30	--

Composite Sample V-1, e_{00} = 7.29, Soil Boring B-6

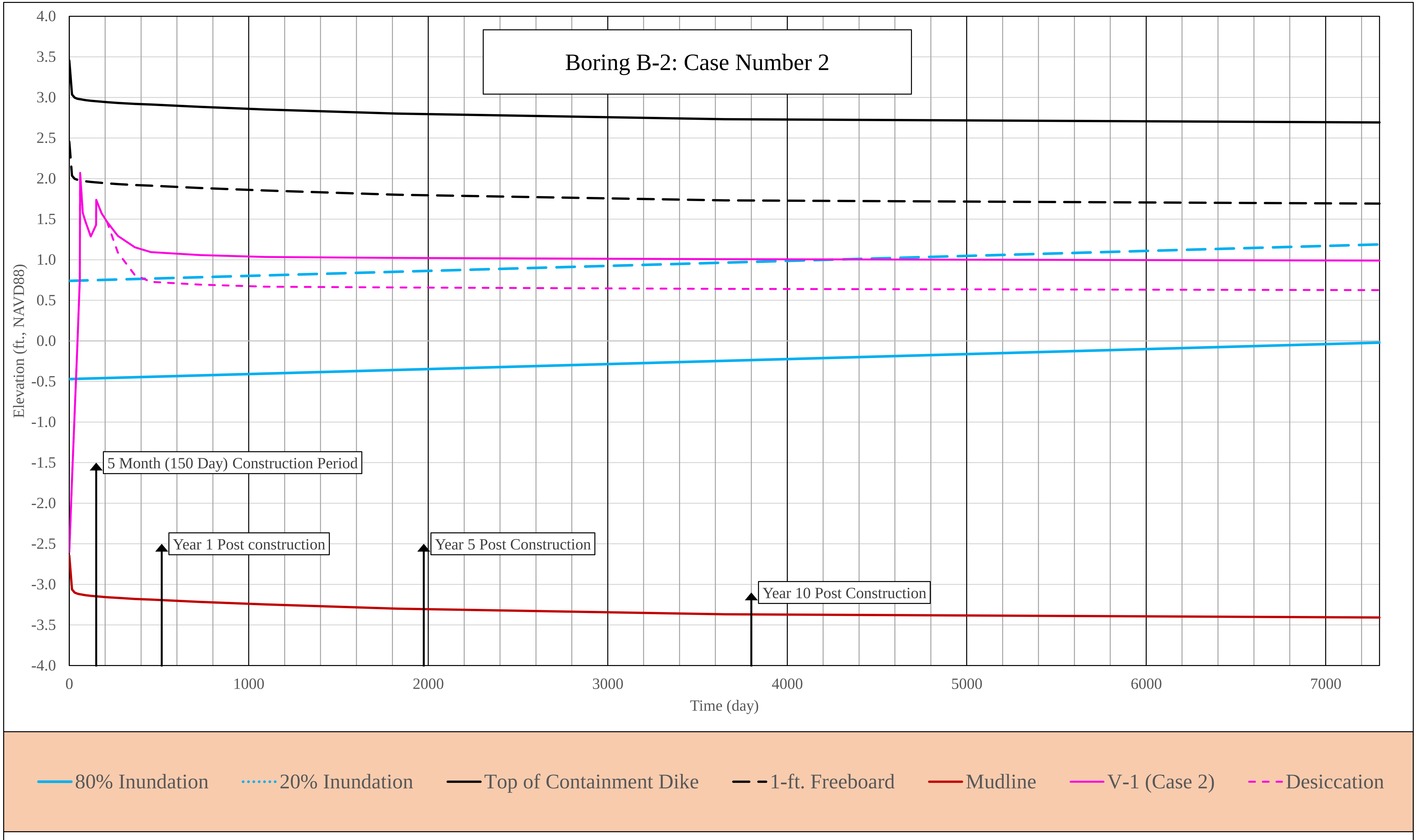
Time	Fill Height
(day)	(ft.)
0	1.4
7	1.4
14	1.4
21	1.4
29	1.4
30	--

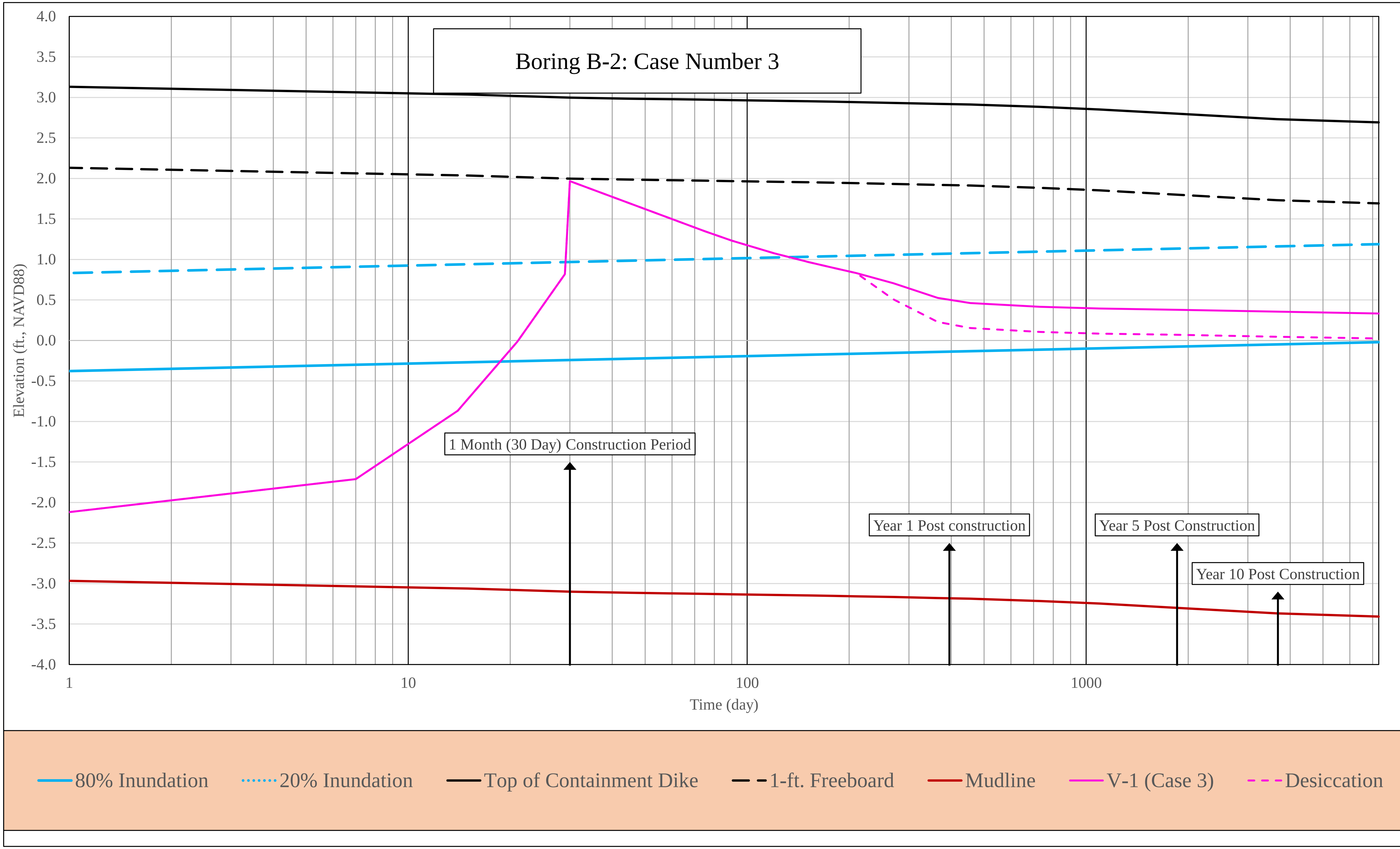

Boring B-2: Case Number 1
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
Elevation (ft., NAVD88)
2 Month (60 Day) Construction Period
Year 1 Post construction
Year 5 Post Construction
Year 10 Post Construction
1
10
100
1000
Time (day)
80% Inundation
20% Inundation
Top of Containment Dike
1-ft. Freeboard
Mudline
V-1 (Case 1)
Desiccation

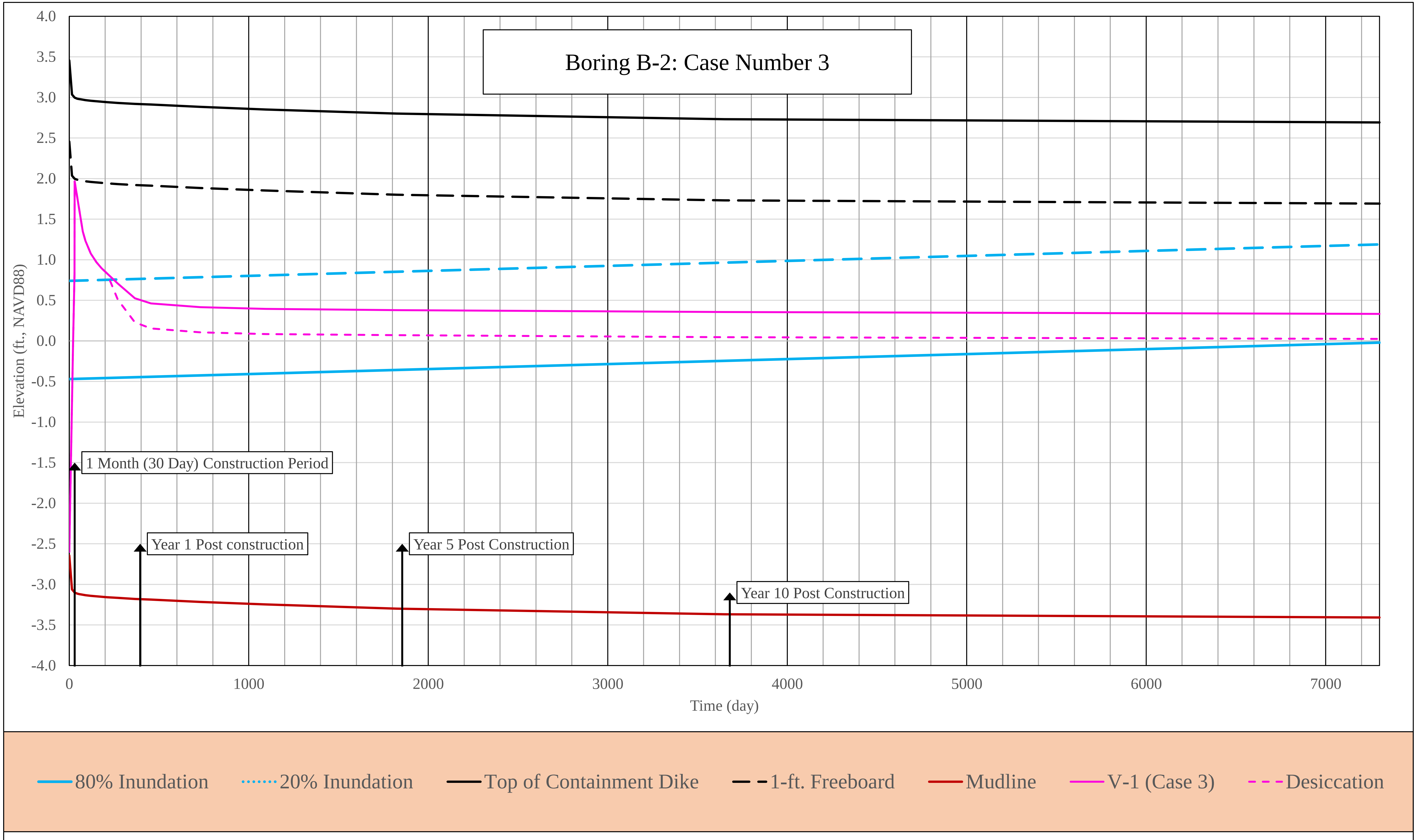

Boring B-2: Case Number 1
Elevation (ft., NAVD88)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
2 Month (60 Day) Construction Period
Year 1 Post construction
Year 5 Post Construction
Year 10 Post Construction
0
1000
2000
3000
4000
5000
6000
7000
Time (day)
80% Inundation
20% Inundation
Top of Containment Dike
1-ft. Freeboard
Mudline
V-1 (Case 1)
Desiccation

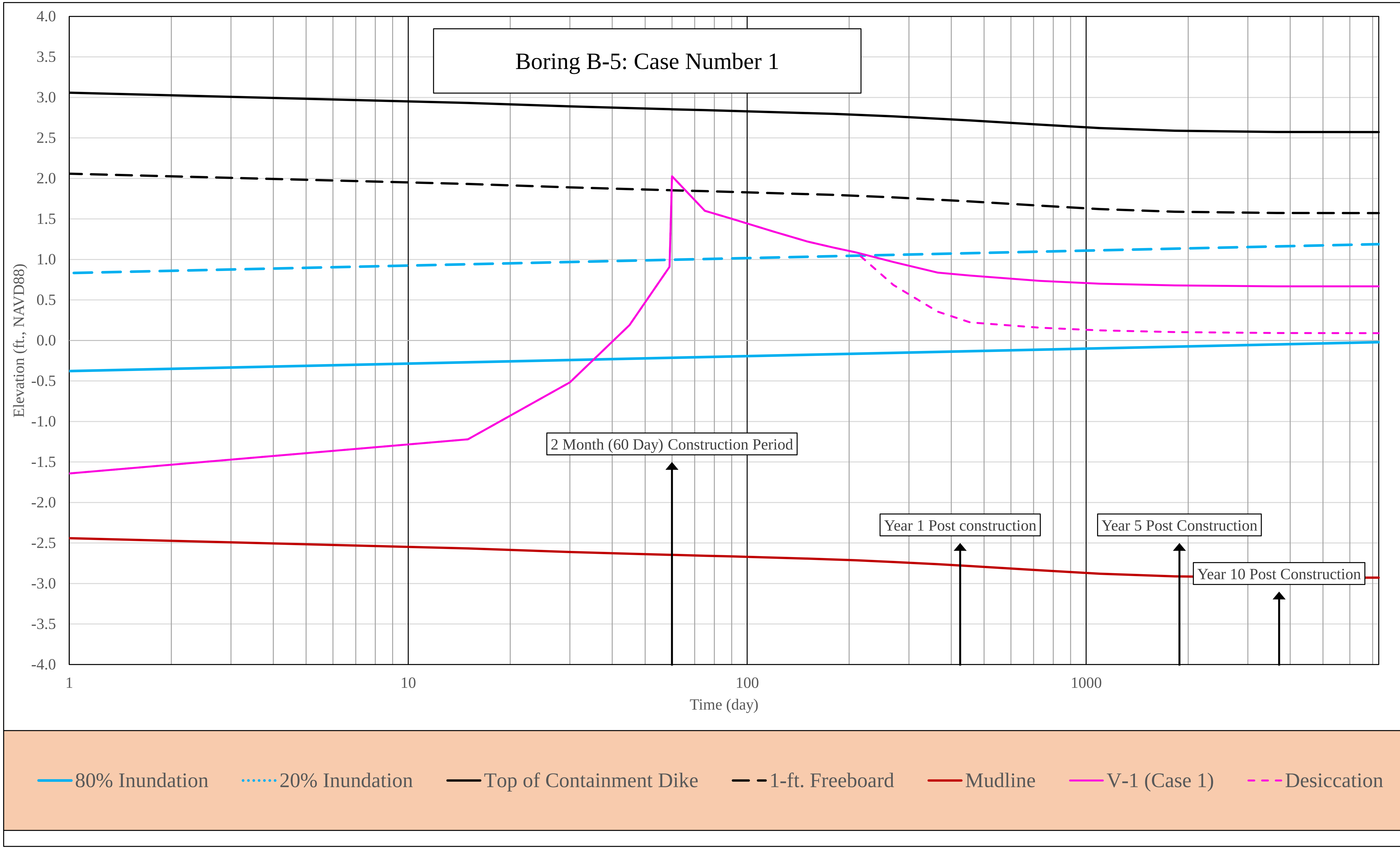


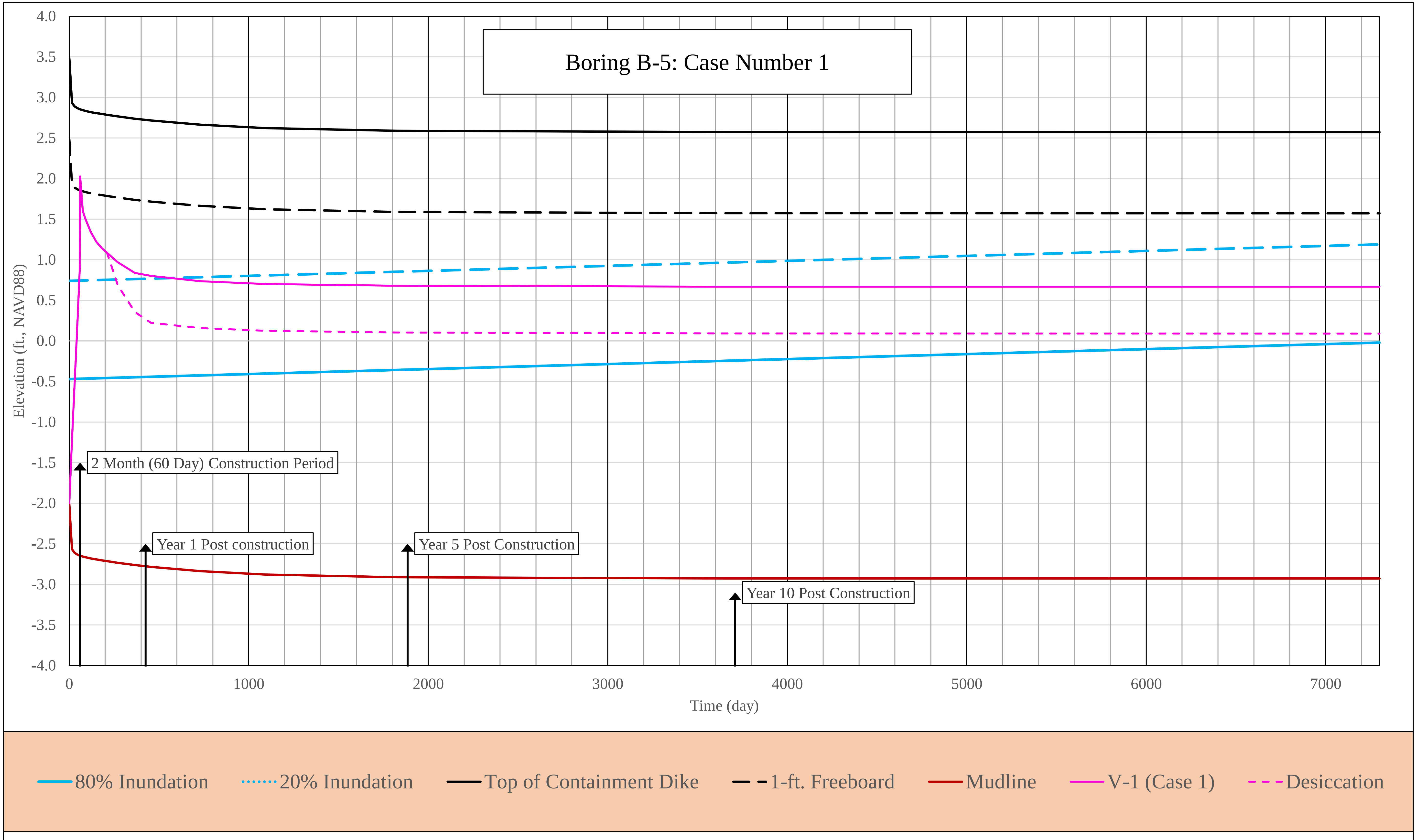
Ardaman & Associates, Inc.

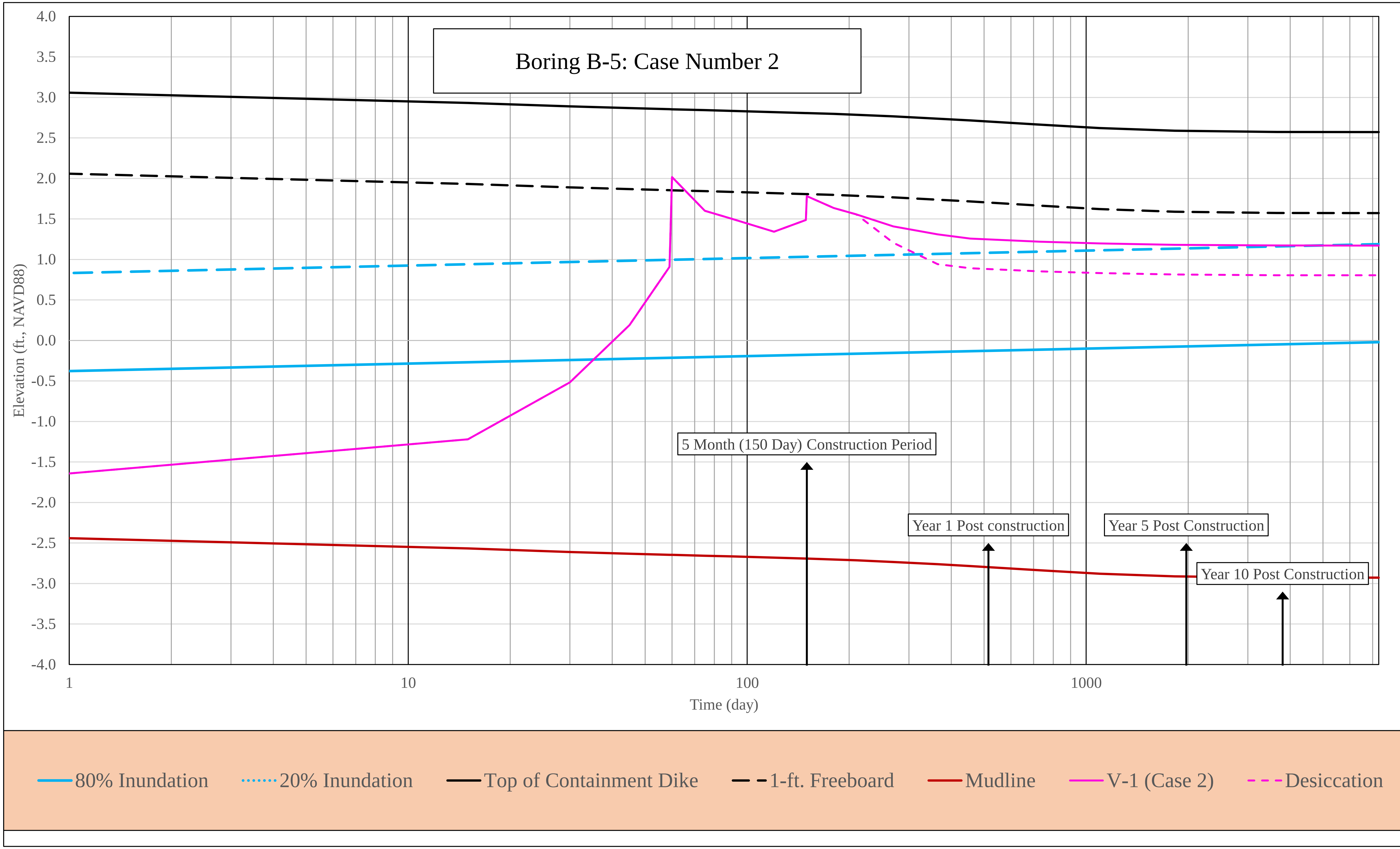

Boring B-2: Case Number 2
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
Elevation (ft., NAVD88)
5 Month (150 Day) Construction Period
Year 1 Post construction
Year 5 Post Construction
Year 10 Post Construction
0
1000
2000
3000
4000
5000
6000
7000
Time (day)
80% Inundation
20% Inundation
Top of Containment Dike
1-ft. Freeboard
Mudline
V-1 (Case 2)
Desiccation

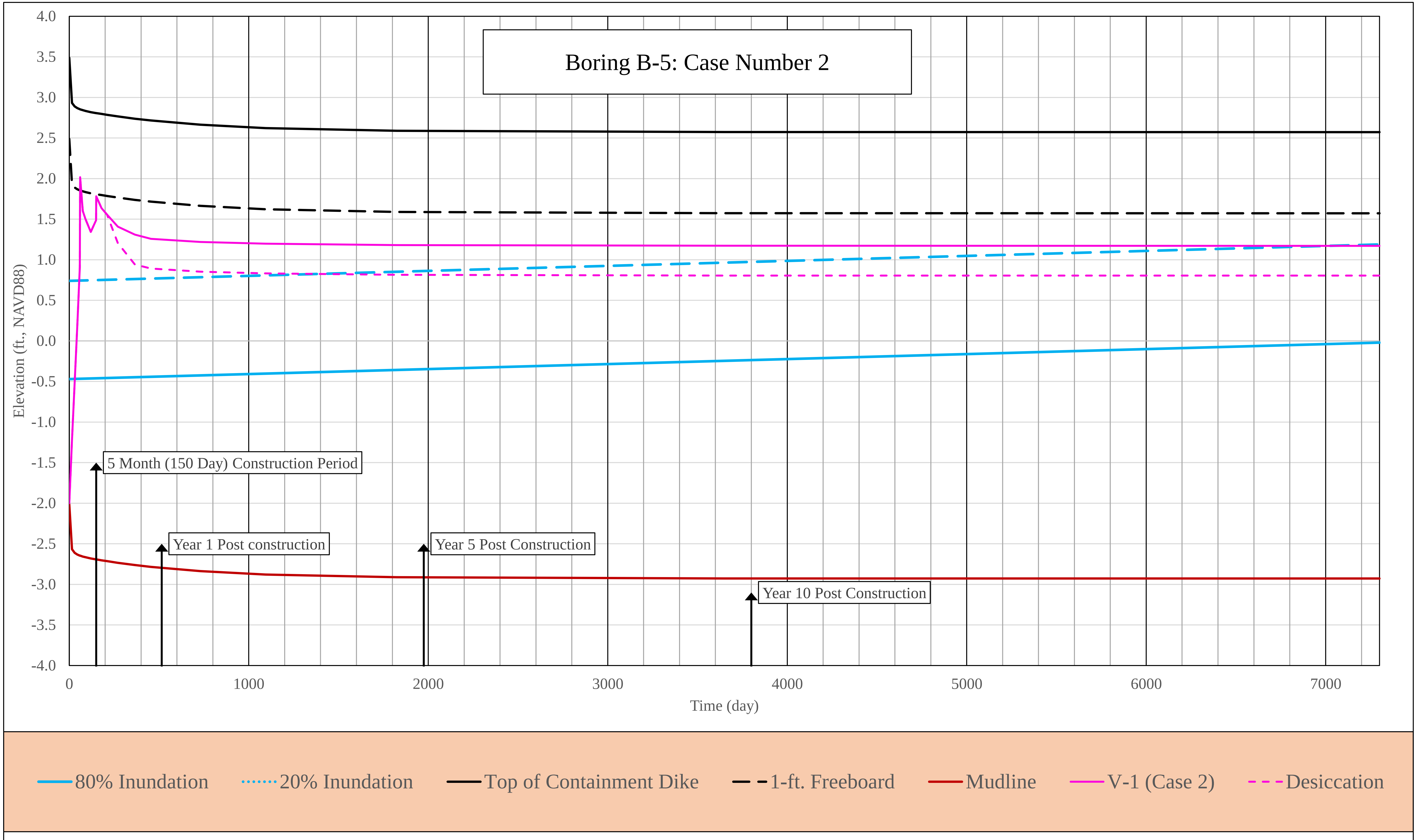

Boring B-2: Case Number 3
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
Elevation (ft., NAVD88)
1
10
100
1000
Time (day)
1 Month (30 Day) Construction Period
Year 1 Post construction
Year 5 Post Construction
Year 10 Post Construction
80% Inundation
20% Inundation
Top of Containment Dike
1-ft. Freeboard
Mudline
V-1 (Case 3)
Desiccation

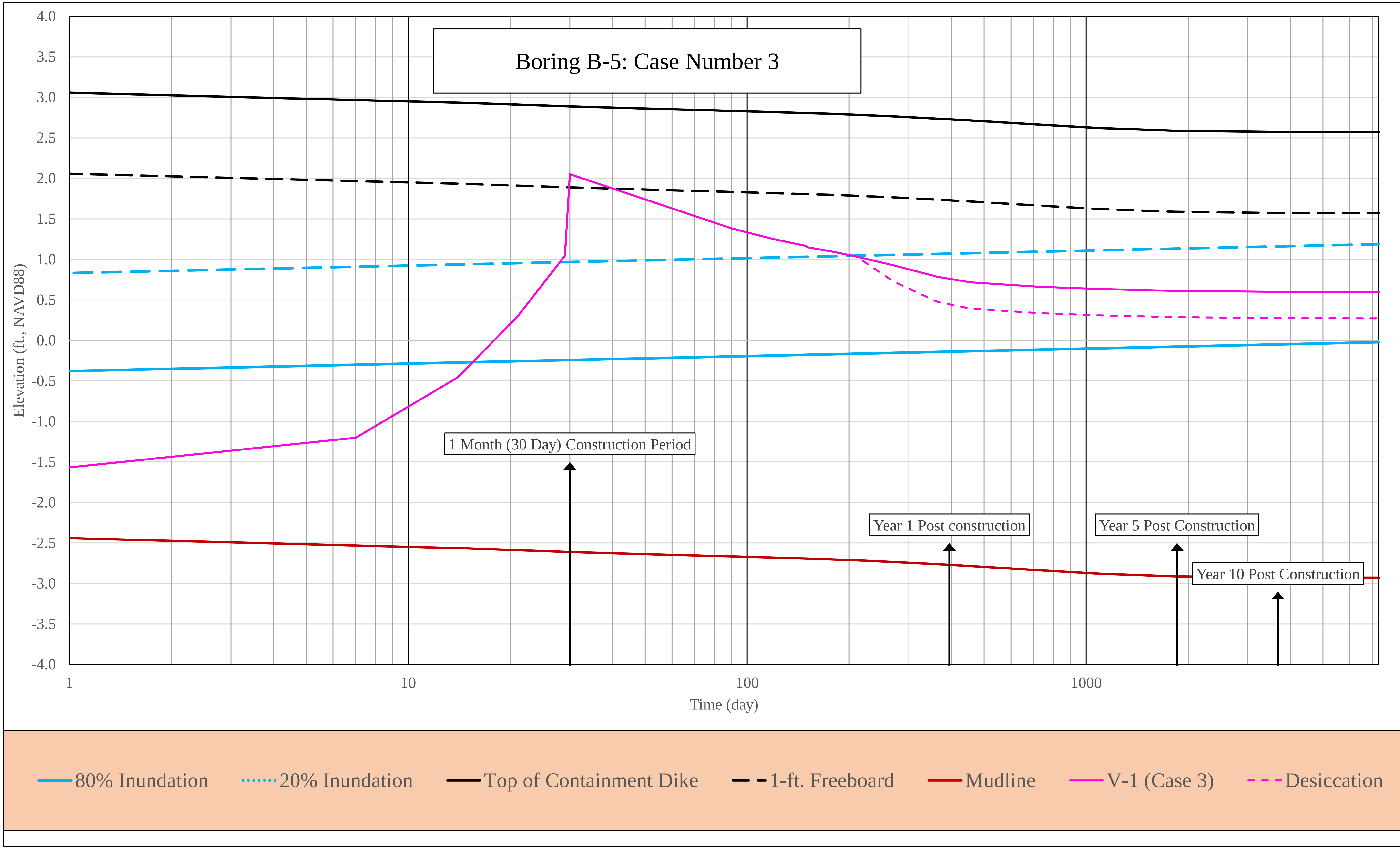

Boring B-2: Case Number 3
Elevation (ft., NAVD88)
Time (day)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
0
1000
2000
3000
4000
5000
6000
7000
1 Month (30 Day) Construction Period
Year 1 Post construction
Year 5 Post Construction
Year 10 Post Construction
80% Inundation
20% Inundation
Top of Containment Dike
1-ft. Freeboard
Mudline
V-1 (Case 3)
Desiccation

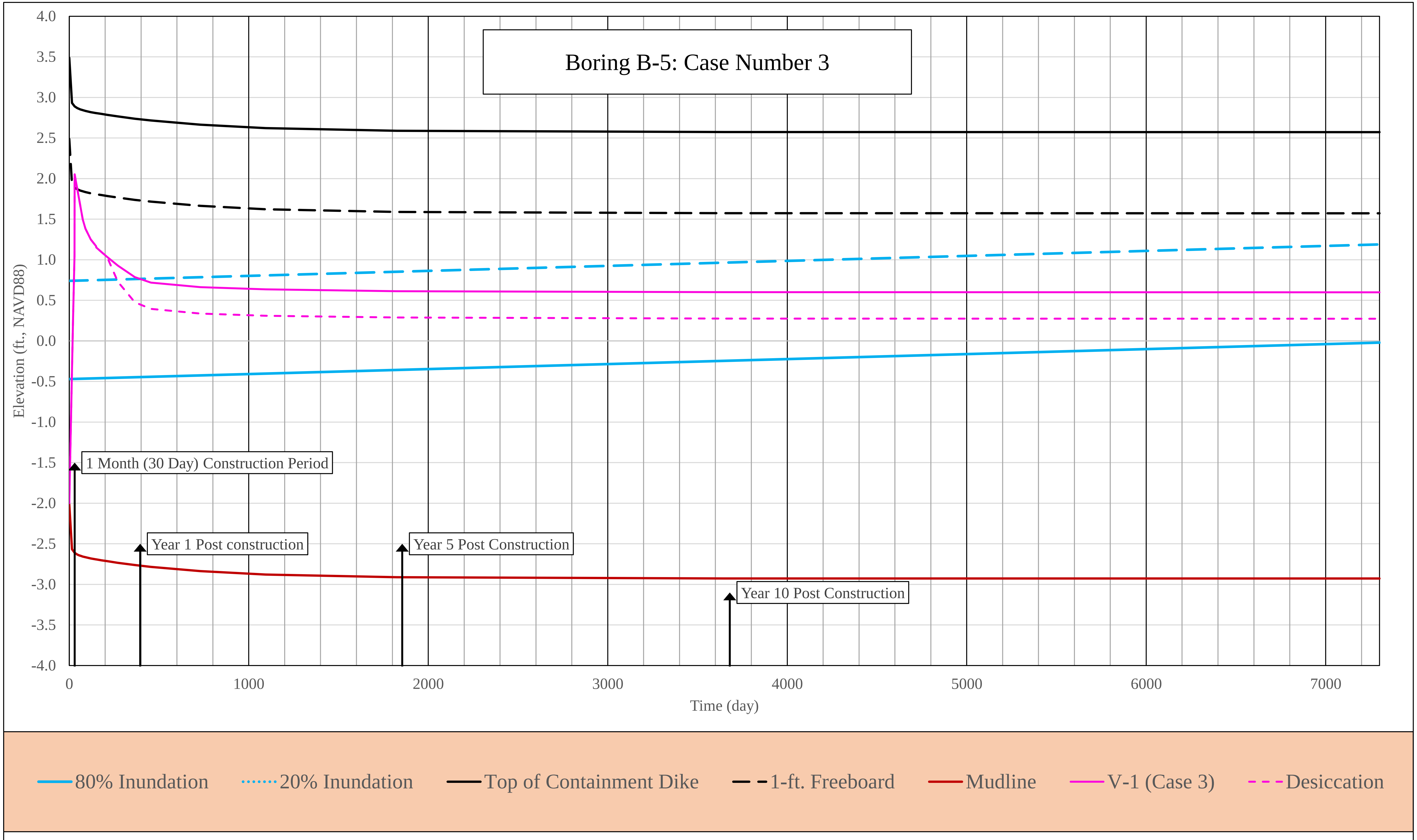

Boring B-5: Case Number 1
Elevation (ft., NAVD88)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
2 Month (60 Day) Construction Period
Year 1 Post construction
Year 5 Post Construction
Year 10 Post Construction
1
10
100
1000
Time (day)
80% Inundation
20% Inundation
Top of Containment Dike
1-ft. Freeboard
Mudline
V-1 (Case 1)
Desiccation

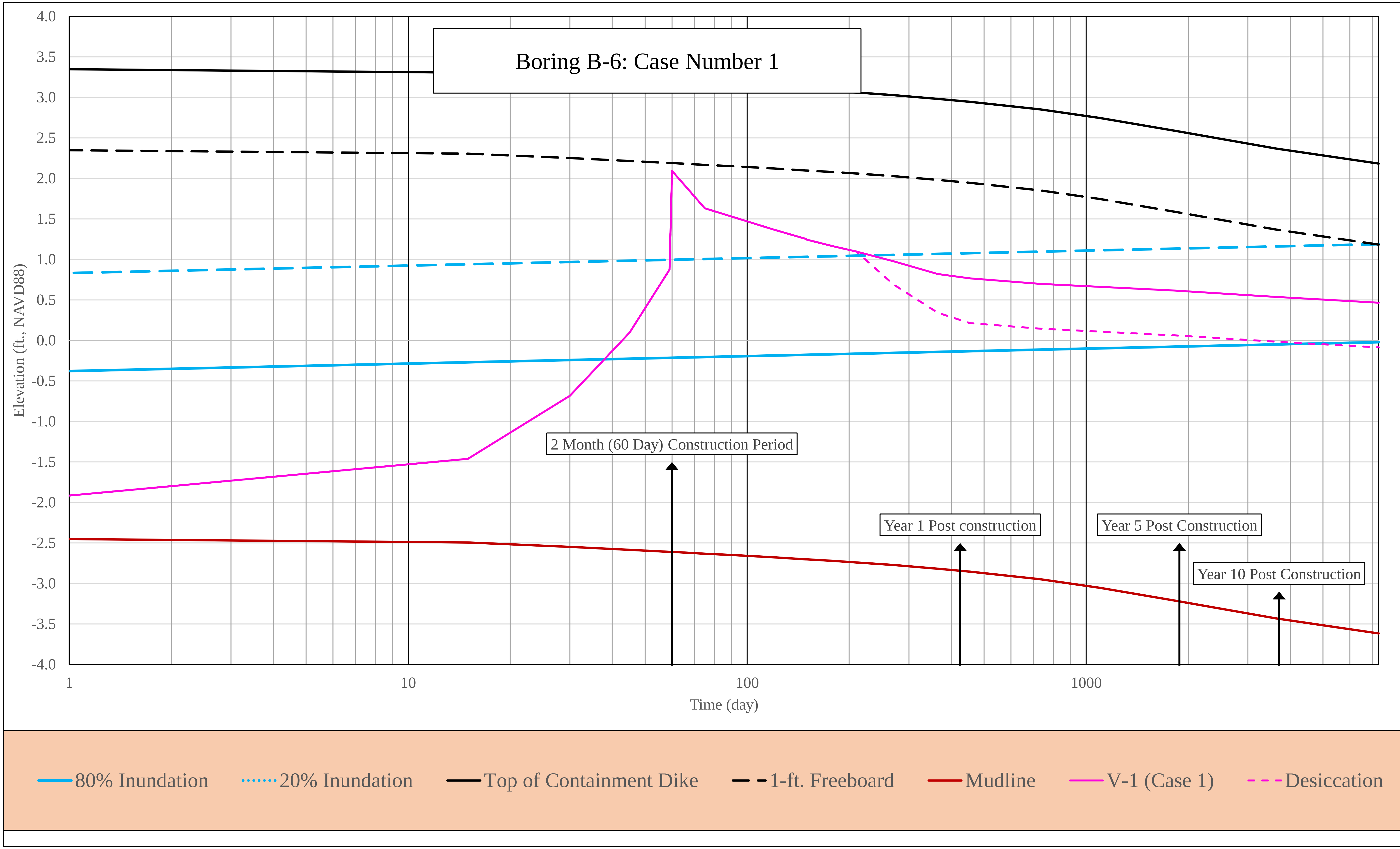

Boring B-5: Case Number 1
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
Elevation (ft., NAVD88)
2 Month (60 Day) Construction Period
Year 1 Post construction
Year 5 Post Construction
Year 10 Post Construction
0
1000
2000
3000
4000
5000
6000
7000
Time (day)
80% Inundation
20% Inundation
Top of Containment Dike
1-ft. Freeboard
Mudline
V-1 (Case 1)
Desiccation

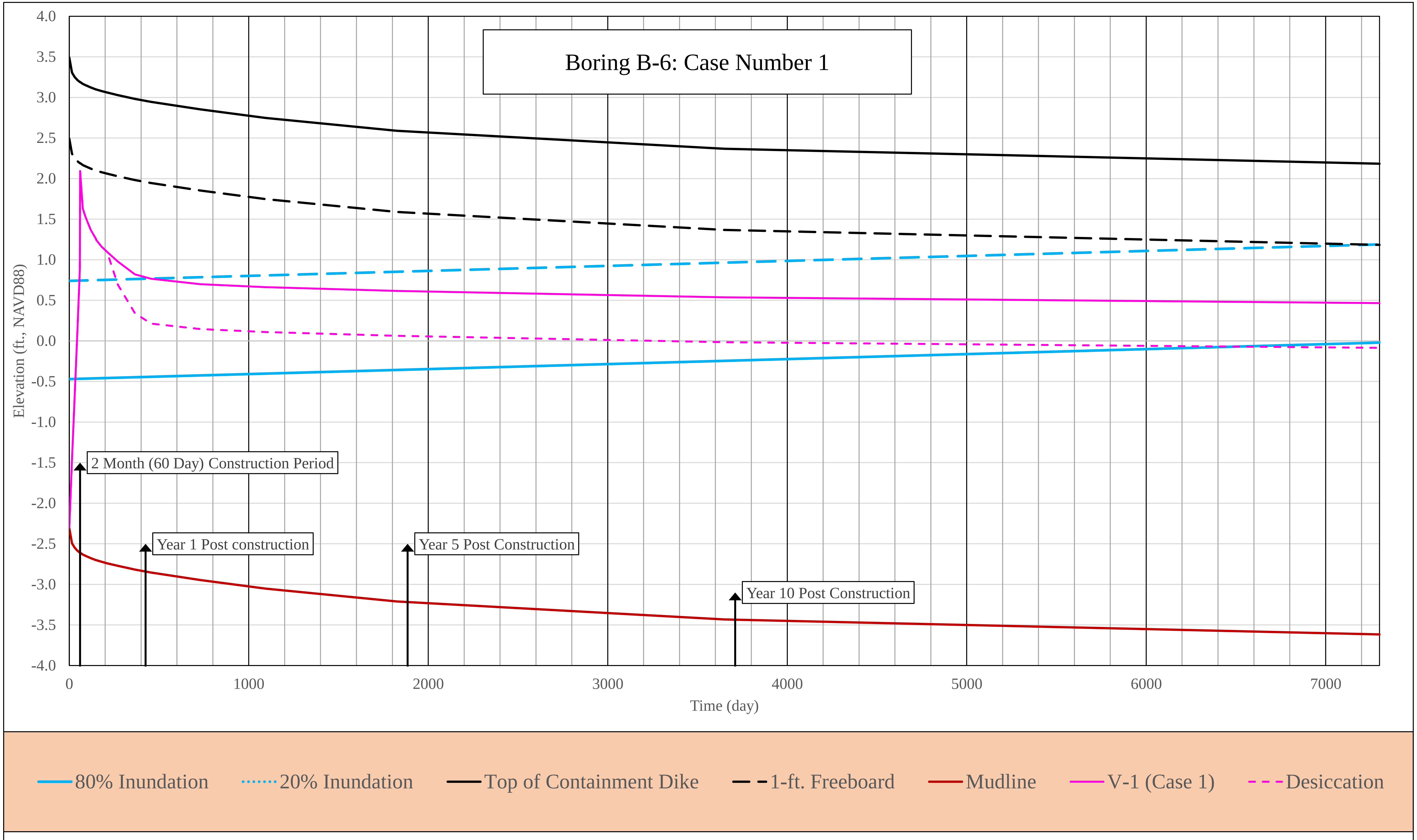

Boring B-5: Case Number 2
Elevation (ft., NAVD88)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
1
10
100
1000
Time (day)
5 Month (150 Day) Construction Period
Year 1 Post construction
Year 5 Post Construction
Year 10 Post Construction
80% Inundation
20% Inundation
Top of Containment Dike
1-ft. Freeboard
Mudline
V-1 (Case 2)
Desiccation

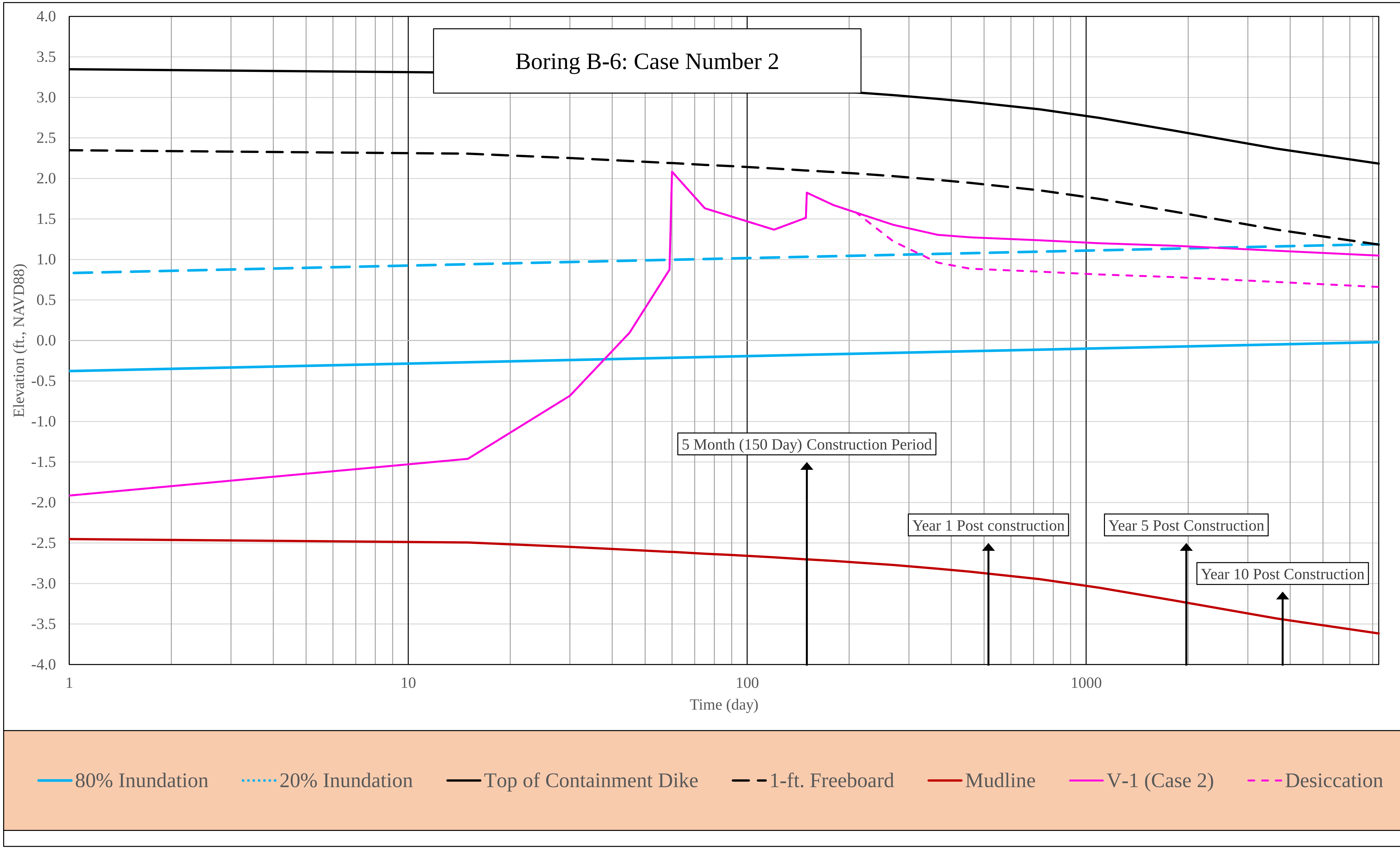

Boring B-5: Case Number 2
Elevation (ft., NAVD88)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
5 Month (150 Day) Construction Period
Year 1 Post construction
Year 5 Post Construction
Year 10 Post Construction
0
1000
2000
3000
4000
5000
6000
7000
Time (day)
80% Inundation
20% Inundation
Top of Containment Dike
1-ft. Freeboard
Mudline
V-1 (Case 2)
Desiccation

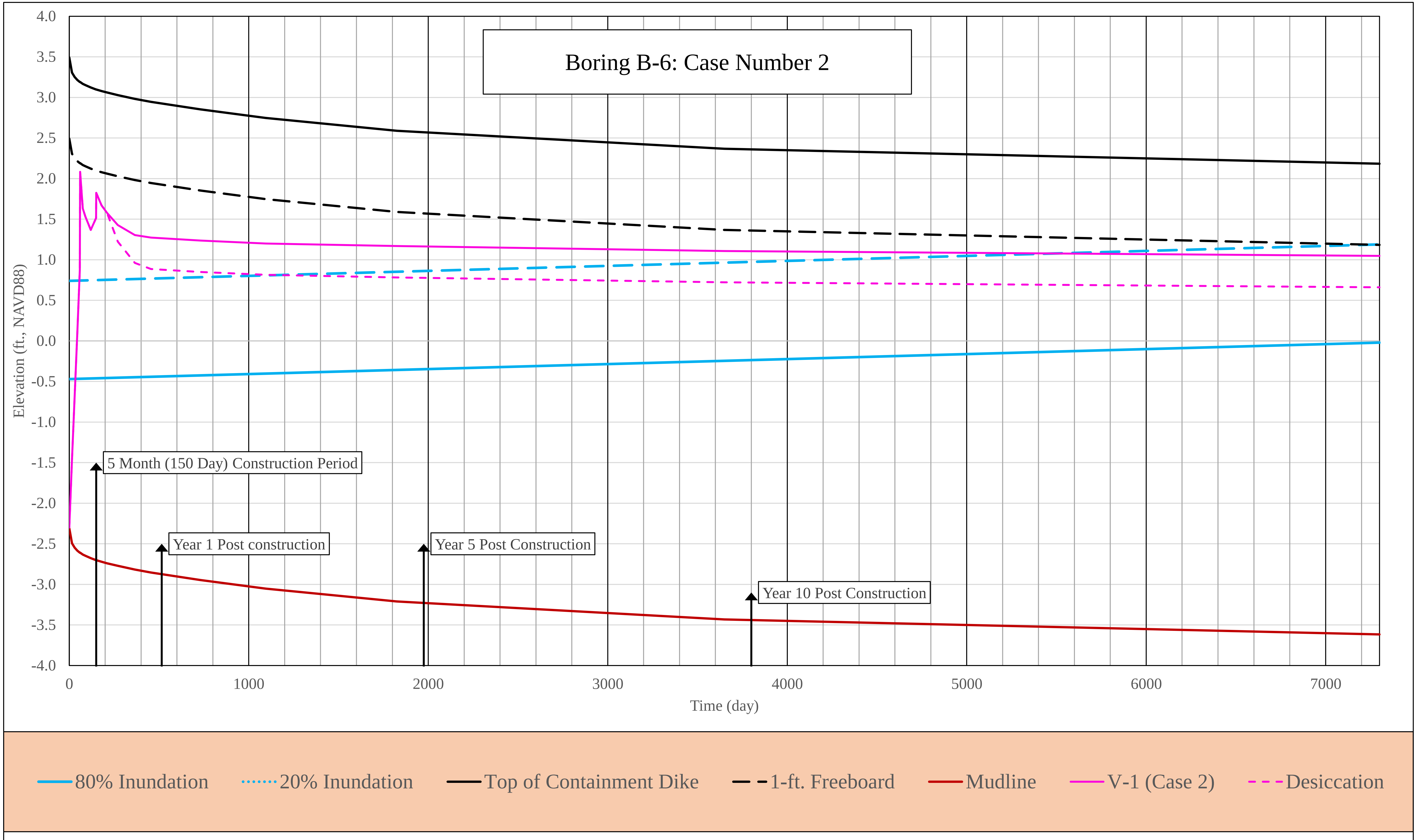

Boring B-5: Case Number 3
Elevation (ft., NAVD88)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
1
10
100
1000
Time (day)
1 Month (30 Day) Construction Period
Year 1 Post construction
Year 5 Post Construction
Year 10 Post Construction
80% Inundation
20% Inundation
Top of Containment Dike
1-ft. Freeboard
Mudline
V-1 (Case 3)
Desiccation

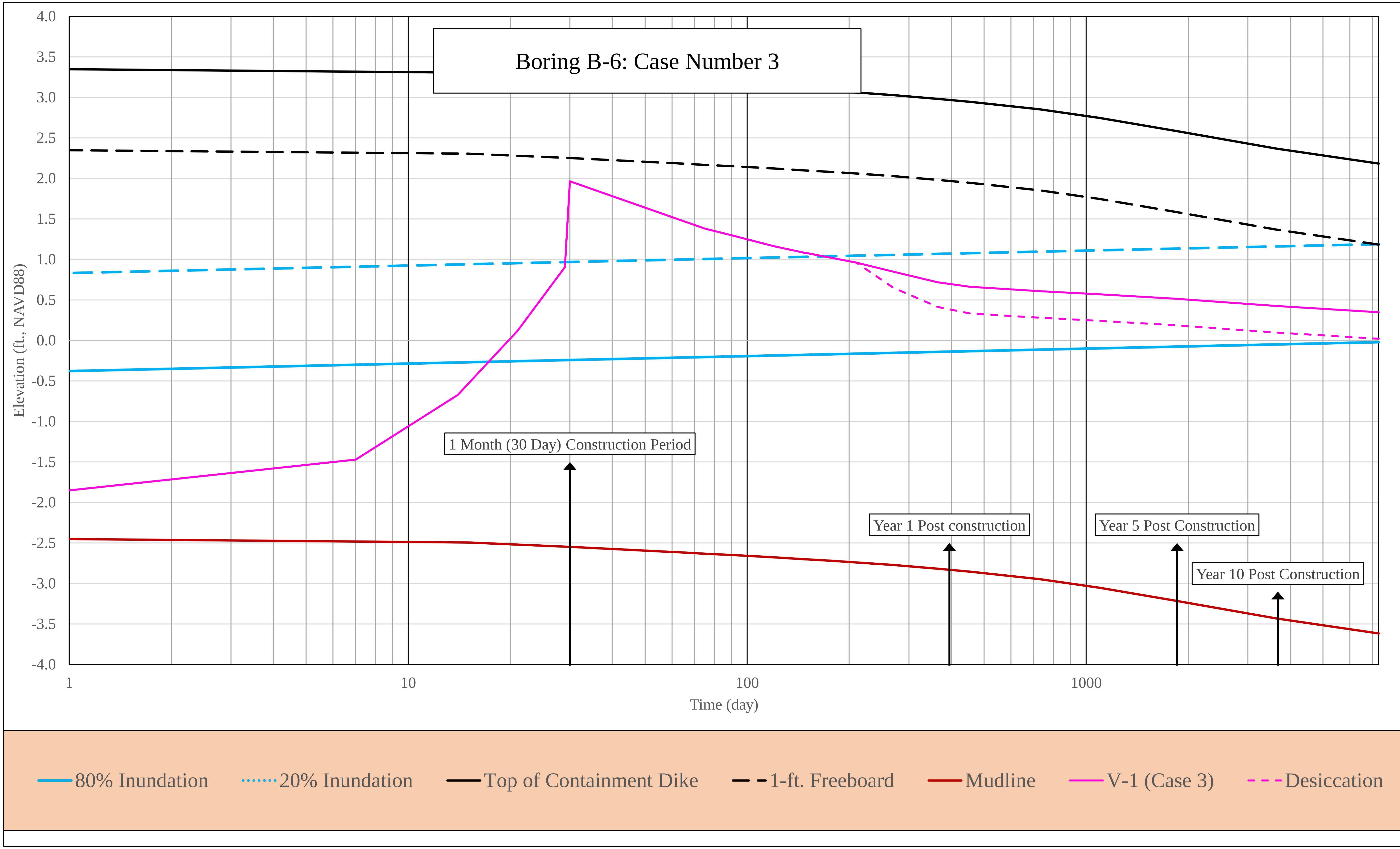

Boring B-5: Case Number 3
Elevation (ft., NAVD88)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
1 Month (30 Day) Construction Period
Year 1 Post construction
Year 5 Post Construction
Year 10 Post Construction
0
1000
2000
3000
4000
5000
6000
7000
Time (day)
80% Inundation
20% Inundation
Top of Containment Dike
1-ft. Freeboard
Mudline
V-1 (Case 3)
Desiccation

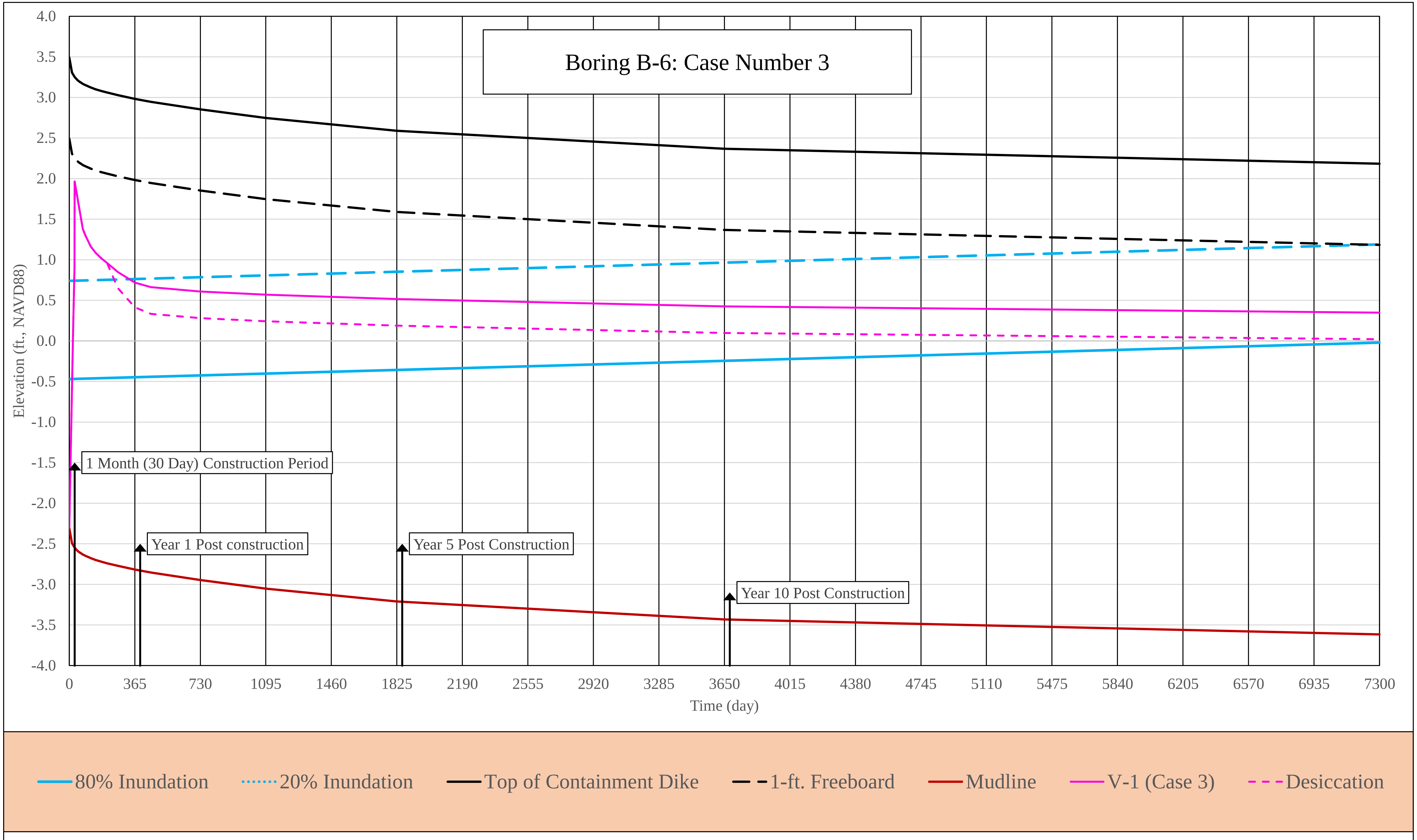

Boring B-6: Case Number 1
Elevation (ft., NAVD88)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
1
10
100
1000
Time (day)
2 Month (60 Day) Construction Period
Year 1 Post construction
Year 5 Post Construction
Year 10 Post Construction
80% Inundation
20% Inundation
Top of Containment Dike
1-ft. Freeboard
Mudline
V-1 (Case 1)
Desiccation


Boring B-6: Case Number 1
Elevation (ft., NAVD88)
Time (day)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
0
1000
2000
3000
4000
5000
6000
7000
2 Month (60 Day) Construction Period
Year 1 Post construction
Year 5 Post Construction
Year 10 Post Construction
80% Inundation
20% Inundation
Top of Containment Dike
1-ft. Freeboard
Mudline
V-1 (Case 1)
Desiccation


Boring B-6: Case Number 2
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
Elevation (ft., NAVD88)
1
10
100
1000
Time (day)
5 Month (150 Day) Construction Period
Year 1 Post construction
Year 5 Post Construction
Year 10 Post Construction
80% Inundation
20% Inundation
Top of Containment Dike
1-ft. Freeboard
Mudline
V-1 (Case 2)
Desiccation


Boring B-6: Case Number 2
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
Elevation (ft., NAVD88)
0
1000
2000
3000
4000
5000
6000
7000
Time (day)
5 Month (150 Day) Construction Period
Year 1 Post construction
Year 5 Post Construction
Year 10 Post Construction
80% Inundation
20% Inundation
Top of Containment Dike
1-ft. Freeboard
Mudline
V-1 (Case 2)
Desiccation


Boring B-6: Case Number 3
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
Elevation (ft., NAVD88)
1 Month (30 Day) Construction Period
Year 1 Post construction
Year 5 Post Construction
Year 10 Post Construction
1
10
100
1000
Time (day)
80% Inundation
20% Inundation
Top of Containment Dike
1-ft. Freeboard
Mudline
V-1 (Case 3)
Desiccation


Boring B-6: Case Number 3
Elevation (ft., NAVD88)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
1 Month (30 Day) Construction Period
Year 1 Post construction
Year 5 Post Construction
Year 10 Post Construction
0
365
730
1095
1460
1825
2190
2555
2920
3285
3650
4015
4380
4745
5110
5475
5840
6205
6570
6935
7300
Time (day)
80% Inundation
20% Inundation
Top of Containment Dike
1-ft. Freeboard
Mudline
V-1 (Case 3)
Desiccation

Appendix A. FINAL GDR – OFFSHORE BORROW AREA

This Appendix contains the following:

A.1 Final Geotechnical Data Report- Field and Laboratory Data Collection Phase: Caminada Headlands Back Barrier Marsh Creation Increment II (BA-193) Offshore Borrow Investigation dated February 9, 2018.

Appendix B. CALCULATION PACKAGE

(Digital Copies Only)

B.1 Soil Boring B-2

- Foundation & Marsh Fill Settlement Case 1
- Foundation & Marsh Fill Settlement Case 2
- Foundation & Marsh Fill Settlement Case 3

B.2 Soil Boring B-5

- Foundation & Marsh Fill Settlement Case 1
- Foundation & Marsh Fill Settlement Case 2
- Foundation & Marsh Fill Settlement Case 3

B.3 Soil Boring B-6

- Foundation & Marsh Fill Settlement Case 1
- Foundation & Marsh Fill Settlement Case 2
- Foundation & Marsh Fill Settlement Case 3